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DRAFT FINAL

**PHASE II RFI/RI WORK PLAN
(Bedrock)**

**ROCKY FLATS PLANT
GOLDEN, COLORADO**

**903 PAD, MOUND AND
EAST TRENCHES AREAS
(Operable Unit No. 2)**

**U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado**

ENVIRONMENTAL RESTORATION PROGRAM

January 1991

ADMIN RECORD

REVIEWED FOR CLASSIFICATION/RI/CI

By *[Signature]*
Date *11/11/91*

E-10

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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION	1-1
1.1 ENVIRONMENTAL RESTORATION PROGRAM	1-1
1.2 WORK PLAN SCOPE	1-2
1.3 REGIONAL AND PLANT SITE BACKGROUND INFORMATION	1-5
1.3.1 Background	1-5
1.3.2 Physical Setting	1-8
1.3.3 Surrounding Land Use and Population Density	1-16
1.3.4 Ecology	1-17
1.4 SITE LOCATIONS AND DESCRIPTIONS	1-18
1.4.1 903 Pad Area	1-18
1.4.2 Mound Area	1-25
1.4.3 East Trenches Area	1-28
1.5 PRIOR SITE CHARACTERIZATION	1-29
1.5.1 Phase I Remedial Investigation	1-29
1.5.2 Recent Geologic Characterization	1-31
1.5.3 Phase II RFI/RI Work Plan (Alluvial)	1-32
2.0 SITE CHARACTERIZATION	2-1
2.1 SITE PHYSICAL CHARACTERISTICS	2-1
2.1.1 Geology	2-1
2.1.2 Groundwater Hydrology	2-15
2.1.3 Surface Water Hydrology	2-34
2.2 NATURE AND EXTENT OF CONTAMINATION	2-35
2.2.1 Introduction	2-35
2.2.2 Background Characterization	2-36
2.2.3 Groundwater	2-59
2.2.4 Bedrock	2-98
2.3 CONCEPTUAL MODEL	2-114
2.3.1 Bedrock Contamination Sources	2-114
2.3.2 Release Mechanisms	2-116

TABLE OF CONTENTS (Continued)

<u>Section</u>		<u>Page</u>
	2.3.3 Potential Exposure Pathways	2-116
	2.3.4 Receptors	2-116
	2.3.5 Summary	2-116
3.0	APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS	3-1
3.1	THE ARAR BASIS	3-1
3.2	THE ARAR PROCESS	3-10
	3.2.1 ARARs	3-10
	3.2.2 TBCs	3-10
	3.2.3 ARAR Categories	3-10
	3.2.4 Feasibility Study ARAR Requirements	3-11
3.3	REMEDIAL ACTION	3-11
	3.3.1 Remediation Goals	3-12
3.4	OPERABLE UNIT 2 BEDROCK GROUNDWATER ARARs	3-13
	3.4.1 Safe Drinking Water Act MCLs	3-13
	3.4.2 RCRA Groundwater Protection Standards	3-13
	3.4.3 Variance Standards	3-14
	3.4.4 Colorado Water Quality Control Commission Groundwater Standards	3-14
	3.4.5 Operable Unit 2 ARARs Summary	3-15
4.0	DATA NEEDS AND DATA QUALITY OBJECTIVES (DQOs)	4-1
4.1	SITE-SPECIFIC RFI/RI DQO PROCESS	4-1
4.2	SUMMARY OF EXISTING SITE DATA AND CONCEPTUAL MODEL	4-2
4.3	SITE-SPECIFIC PHASE II RFI/RI (BEDROCK) OBJECTIVES AND DATA NEEDS	4-3
5.0	REMEDIAL INVESTIGATION TASKS	5-1
5.1	TASK 1 - PROJECT PLANNING	5-1
5.2	TASK 2 - COMMUNITY RELATIONS	5-1
5.3	TASK 3 - FIELD INVESTIGATION	5-2
5.4	TASK 4 - SAMPLE ANALYSIS AND DATA VALIDATION	5-3

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
5.5 TASK 5 - DATA EVALUATION	5-3
5.5.1 Site Characterization	5-3
5.5.2 Source Characterization	5-3
5.5.3 Nature and Extent of Contamination	5-4
5.6 TASK 6 - BASELINE RISK ASSESSMENT	5-4
5.6.1 Public Health Evaluation	5-5
5.6.2 Environmental Evaluation	5-9
5.7 TASK 7 - TREATABILITY STUDIES	5-10
5.8 TASK 8 - REMEDIAL INVESTIGATION REPORT	5-14
6.0 FEASIBILITY STUDY TASKS	6-1
6.1 TASK 9 - REMEDIAL ALTERNATIVES DEVELOPMENT/SCREENING	6-1
6.2 TASK 10 - DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES	6-6
6.3 TASK 11 - FEASIBILITY STUDY REPORT	6-9
7.0 SCHEDULE	7-1
8.0 FIELD SAMPLING PLAN	8-1
8.1 BACKGROUND	8-1
8.2 FIELD SAMPLING	8-2
8.2.1 Sampling Rationale	8-2
8.2.2 Boreholes	8-5
8.2.3 Groundwater Monitoring Wells	8-18
8.2.4 Location Surveying	8-20
8.2.5 Data Reporting Requirements	8-20
8.3 SAMPLE ANALYSIS	8-20
8.3.1 Soil Samples from Boreholes	8-20
8.3.2 Groundwater Samples	8-27
8.3.3 Sample Containers and Preservation, and Sample Control and Documentation	8-27
8.3.4 Field QC Procedures	8-30

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
9.0 QUALITY ASSURANCE ADDENDUM (QAA)	9-1
9.1 ORGANIZATION AND RESPONSIBILITIES	9-1
9.2 QUALITY ASSURANCE PROGRAM	9-1
9.3 DESIGN CONTROL	9-3
9.3.1 Data Quality Objectives (DQOs)	9-3
9.3.2 Sampling Locations	9-17
9.3.3 Hydrologic Testing	9-17
9.3.4 Equipment Decontamination	9-17
9.3.5 Quality Control Checks	9-17
9.3.6 Analytical Procedures	9-17
9.3.7 Data Reduction, Validation, and Reporting	9-22
9.4 PROCUREMENT DOCUMENT CONTROL	9-22
9.5 INSTRUCTIONS, PROCEDURES, AND DRAWINGS	9-24
9.6 DOCUMENT CONTROL	9-24
9.7 CONTROL OF PURCHASED ITEMS AND SERVICES	9-24
9.8 IDENTIFICATION AND CONTROL OF ITEMS, SAMPLES, AND DATA	9-25
9.8.1 Sample Containers/Preservation	9-25
9.8.2 Sample Identification	9-25
9.8.3 Chain-of-Custody	9-25
9.9 CONTROL OF PROCESSES	9-25
9.10 INSPECTION	9-25
9.11 TEST CONTROL	9-25
9.12 CONTROL OF MEASURING AND TEST EQUIPMENT (M&TE)	9-26
9.12.1 Field Equipment	9-26
9.12.2 Laboratory Equipment	9-26
9.13 HANDLING, STORAGE, AND SHIPPING	9-26
9.14 STATUS OF INSPECTION, TEST, AND OPERATIONS	9-29
9.15 CONTROL OF NONCONFORMANCES	9-29
9.16 CORRECTIVE ACTION	9-29
9.17 QUALITY ASSURANCE RECORDS	9-29
9.18 QUALITY VERIFICATION	9-30
9.19 SOFTWARE CONTROL	9-30

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
10.0 SOP ADDENDA (SOPA)	10-1
10.1 SOP ADDENDUM TO SOP NO. 2.6	10-1
10.1.1 Introduction	10-1
10.1.2 Determination of the Depth and Thickness of Non-Aqueous Phase Immiscible Layers	10-1
10.1.3 Collection of Non-Aqueous Phase Liquid Samples	10-1
10.2 SOP ADDENDUM TO SOP NO. 3.9	10-2
10.2.1 Introduction	10-2
10.2.2 Obtaining and Preparing Samples	10-3
11.0 REFERENCES	11-1

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
 <u>LIST OF TABLES</u>	
TABLE 2-1	Summary of Boreholes and Wells in Operable Unit 2 Used For Bedrock Work Plan
	2-16
TABLE 2-2A	Statistics For Dissolved Metal Concentrations in Background Weathered Claystone Groundwater Samples
	2-37
TABLE 2-2B	Statistics For Inorganic Concentrations in Background North Rocky Flats Weathered Claystone Groundwater Samples
	2-38
TABLE 2-2C	Statistics For Concentrations in Background Weathered Claystone Groundwater Samples
	2-39
TABLE 2-2D	Statistics For Concentrations in Background South Rocky Flats Weathered Claystone Groundwater Samples
	2-40
TABLE 2-2E	Statistics For Dissolved Radiochemical Concentrations in Background Weathered Sandstone Groundwater Samples
	2-41
TABLE 2-3A	Statistics for Dissolved Metal Concentrations in Background Weathered Sandstone Groundwater Samples
	2-43
TABLE 2-3B	Statistics For Inorganic Concentrations in Background Weathered Sandstone Groundwater Samples
	2-44
TABLE 2-3C	Statistics For Inorganic Concentrations in Background South Rocky Flats Weathered Sandstone Groundwater Samples
	2-45
TABLE 2-3D	Statistics For Dissolved Radiochemical Concentrations in Background Weathered Sandstone Groundwater Samples
	2-46
TABLE 2-4A	Statistics For Dissolved Metal Concentrations in Background Unweathered Sandstone Groundwater Samples
	2-47
TABLE 2-4B	Statistics For Inorganic Concentrations in Background Unweathered Sandstone Groundwater Samples
	2-48
TABLE 2-4C	Statistics For Inorganic Concentrations in Background Northern Rocky Flats Unweathered Sandstone Groundwater Samples
	2-49
TABLE 2-4D	Statistics For Inorganic Concentrations in Background South Rocky Flats Unweathered Sandstone Groundwater Samples
	2-50
TABLE 2-4E	Statistics For Dissolved Radiochemical Concentrations in Background Unweathered Sandstone Groundwater Samples
	2-51
TABLE 2-5A	Summary of Wells Used For Background Concentrations of Dissolved Metals
	2-53
TABLE 2-5B	Summary of Wells Used For Background Concentrations of Inorganics
	2-55
TABLE 2-5C	Summary of Wells Used For Background Evaluation of Groundwater Radiochemistry
	2-57
TABLE 2-6	Summary of Volatile Organic Compounds Detected in Selected Groundwater Monitoring Wells Screened in the Upper and Lower HSUs
	2-61
TABLE 2-7	Summary of Dissolved Radionuclide Concentrations Detected in Selected Groundwater Monitoring Wells Screened in the Upper and Lower HSUs
	2-71
TABLE 2-8A	Summary of Dissolved Inorganic Elements Detected in Selected Groundwater Monitoring Wells Screened in the Upper and Lower HSUs (Aluminum-Chromium)
	2-79

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
TABLE 2-8B Summary of Dissolved Inorganic Elements Detected in Selected Groundwater Monitoring Wells Screened in the Upper and Lower HSUs (Cobalt-Molybdenum)	2-85
TABLE 2-8C Summary of Dissolved Inorganic Elements Detected in Selected Groundwater Monitoring Wells Screened in the Upper and Lower HSUs (Nickel-Zinc)	2-91
TABLE 2-9 Summary of Non-Metallic Inorganic Compounds Detected in Selected Groundwater Monitoring Wells Screened in the Upper and Lower HSUs	2-99
TABLE 2-10 Summary of Volatile Organic Compounds Detected in Bedrock Samples from Boreholes	2-106
TABLE 2-11 Summary of Semi-Volatile Organic Compounds Detected in Soil Samples from Boreholes Drilled into Bedrock	2-110
TABLE 3-1 Proposed Chemical-Specific ARARS for Compounds and Elements Detected in Bedrock Groundwater at the 903 Pad, Mound, and East Trenches	3-2
TABLE 4-1 Data Needs and Data Quality Objectives (DQOS)	4-4
TABLE 4-2 Summary of Analytical Terms	4-8
TABLE 6-1 General Response Actions, Typical Associated Remedial Technologies, and Evaluation	6-4
TABLE 8-1 Proposed Wells and Boreholes Phase II RFI/RI Bedrock Characterization Operable Unit 2	8-6
TABLE 8-2 Soil, Bedrock, and Groundwater Sampling Analytes and Compounds Operable Unit 2	8-21
TABLE 8-3 Samples Types, Containers, and Preservatives for Water and Soils Samples	8-28
TABLE 8-4 Field QC Sample Frequency	8-31
TABLE 9-1 Analytical Methods, Detection Limits, and Data Quality Objectives	9-4
TABLE 9-2 Applicable SOPs	9-18
TABLE 9-3 Field QC Sample Collection Frequency	9-21
TABLE 9-4 Data Validation Guidelines	9-23
TABLE 9-5 Sample Containers, Sample Preservation, and Holding Times for Water, Soil, and Sediments	9-27

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
 <u>LIST OF FIGURES</u>	
FIGURE 1-1 Conceptual Boundary Between "Alluvial" and "Bedrock" Components of RFI/RI	1-4
FIGURE 1-2 Location of Rocky Flats Plant	1-9
FIGURE 1-3 Rocky Flats Plant Boundary and Buffer Zone	1-10
FIGURE 1-4 Generalized Stratigraphic Section of Denver Basin Bedrock	1-11
FIGURE 1-5 Local Stratigraphic Section of Rocky Flats Plant	1-12
FIGURE 1-6 Erosional Surfaces and Alluvial Terrace Deposits East of the Front Range, Colorado	1-14
FIGURE 1-7 Site Plan	1-19
FIGURE 1-8 Approximate Locations of Drum Storage-903 Pad Drum Storage Site	1-21
FIGURE 1-9 Existing Boreholes and Wells	1-30
FIGURE 2-1 Surficial Geology Map	2-2
FIGURE 2-2 Bedrock Surface Contour Map	2-3
FIGURE 2-3 Estimated Lateral Extent and Thickness of Arapahoe Formation Sandstone No. 1	2-6
FIGURE 2-4 Estimated Lateral Extent of Arapahoe Formation Sandstone No. 3, Subcropping Areas and Seismic Survey Summary Results	2-7
FIGURE 2-5 Estimated Lateral Extent of Arapahoe Formation Sandstone No. 4, Subcropping Areas and Seismic Survey Summary Results	2-8
FIGURE 2-6A Geologic Cross Section A-A'	2-9
FIGURE 2-6B Geologic Cross Section A-A'	2-10
FIGURE 2-7A Geologic Cross Section B-B'	2-11
FIGURE 2-7B Geologic Cross Section B-B'	2-12
FIGURE 2-8A Geologic Cross Section G-G'	2-13
FIGURE 2-8B Geologic Cross Section G-G'	2-14
FIGURE 2-9 Upper Hydrostratigraphic Unit (HSU) Bottom Surface Contour Map	2-19
FIGURE 2-10 Potential Areas of Subcropping Arapahoe Formation Sandstone Nos. 2, 3 and 4 with Surface Water Sampling Stations Identified as Seeps	2-21
FIGURE 2-11 Potentiometric Surface of Upper Hydrostratigraphic Unit (HSU)	2-22
FIGURE 2-12 Well Hydrographs (Lower 881 Hillside)	2-25
FIGURE 2-13 Well Hydrographs (South 903 Pad Area)	2-26
FIGURE 2-14 Well Hydrographs (903 Pad Area)	2-27
FIGURE 2-15 Well Hydrographs (Mound Area)	2-28
FIGURE 2-16 Well Hydrographs (West-East Trenches Area)	2-29
FIGURE 2-17 Well Hydrographs (West Central-East Trenches Area)	2-30
FIGURE 2-18 Well Hydrographs (Central-East Trenches Area)	2-31
FIGURE 2-19 Well Hydrographs (South Central-East Trenches Area)	2-32
FIGURE 2-20 Well Hydrographs (East-East Trenches Area)	2-33
FIGURE 2-21 Carbon Tetrachloride Isopleths for the Upper Hydrostratigraphic Unit	2-66
FIGURE 2-22 Tetrachloroethylene Isopleths for the Upper Hydrostratigraphic Unit	2-67
FIGURE 2-23 Trichloroethylene Isopleths for the Upper Hydrostratigraphic Unit	2-69
FIGURE 2-24 Site Conceptual Model	2-115
FIGURE 7-1 Phase II RFI/RI Schedule	7-2

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
FIGURE 8-1 Proposed Borehole/Well Cluster Locations For Initial Boring and Sampling Program	8-3
FIGURE 8-2 Scope and Sequencing of Bedrock RFI/RI Steps	8-4
FIGURE 9-1 Project Management Organization	9-2

TABLE OF CONTENTS (Continued)

LIST OF ACRONYMS

The following is a list of acronyms used throughout this work plan.

ACL	Alternative Concentration Limit
AEC	U.S. Atomic Energy Commission
ARAR	applicable or relative and appropriate requirement
AWQC	Ambient Water Quality Criteria
CAD	Corrective Action Decision
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMS	corrective measures study
CRP	Community Relations Plan
CWA	Clean Water Act
DOE	U.S. Department of Energy
DOO	data quality objective
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ERDA	Energy Research and Development Administration
FIDLER	Field Instrument for Detection of Low Energy Radiation
FS	feasibility study
FSP	field sampling plan
GAC	granular activated carbon
GC	gas chromatograph
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
HSU	hydrostratigraphic unit
IAG	InterAgency Agreement
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MSL	mean sea level
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
PCE	tetrachloroethylene
QAA	Quality Assurance Addendum
QAPjP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
RI	remedial investigation (CERCLA)
ROD	Record of Decision
SAP	sampling and analysis plan
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SOPA	Standard Operating Procedure Addendum

TABLE OF CONTENTS (Concluded)

TAL	Target Analyte List
TBC	to be considered
TCE	trichloroethylene
TCL	Target Compound List
TDS	Total Dissolved Solids
VOC	volatile organic compounds
WQCC	Water Quality Control Commission

conductivity of the unweathered claystone impedes the downward flow of groundwater. There is geologic evidence (i.e., the presence of channel sandstone deposits) that the majority of groundwater flow that occurs may be laterally to the east. There may be a potential for contaminated groundwater in the upper HSU to enter lower bedrock sandstones where they subcrop in localized areas beneath relatively shallow colluvium south and southeast of the 903 Pad area. In general, however, the lower HSU(s) is incompletely modeled.

Based on the Phase I RI results and earlier studies, carbon tetrachloride (CCl₄), tetrachloroethylene (PCE), and trichloroethylene (TCE) are the primary volatile organic contaminants found in the upper HSU in Operable Unit 2. Trace elements occasionally exceeding background levels include barium, copper, nickel, manganese, and zinc. Major anions are somewhat elevated above background throughout and downgradient of the 903 Pad, Mound, and East Trenches areas. Radionuclide levels in the upper HSU are generally within the tolerance limits for the background groundwater data, but a few samples indicate minimum detectable amounts of plutonium and americium in the vicinity of the 903 Pad and possibly north of the Mound. These conclusions are based almost entirely on unvalidated data.

There are 20 existing wells in Operable Unit 2 that are screened entirely within the depth intervals believed to represent the lower (bedrock) HSU(s). These 20 monitoring wells all were constructed since 1986 and have a relatively complete quarterly sampling program. At least six additional pre-1986 wells are also present in Operable Unit 2. Construction details on these wells are not available. The pre-1986 wells have not been used recently for obtaining groundwater quality samples. Volatile organic compounds (VOCs) have been detected in 4 of the 20 recent wells (1887 BR, 2087 BR, 3487 BR, and 4086) that are believed to represent the groundwater chemistry of the lower HSU(s). Only 12 of the 20 wells have available laboratory test data. The measured concentrations of VOCs were as high as 140 µg/l in one of these wells and under 20 µg/l in the other 3 wells. The primary contaminants that were tentatively identified in these wells are TCE and PCE. Other volatile and semivolatile organic and inorganic compounds that have been identified in the upper HSU have generally not been identified in the bedrock. Most of the available analytical data for the bedrock have not been validated.

All of the maximum contaminant levels identified in the lower-HSU wells are based on unvalidated data, and, therefore, the quality of the data is unknown. The unvalidated data have been included in this work plan and utilized for planning because, without the use of this data, there would be a very limited basis for making initial decisions, from a chemical contamination standpoint, in determining locations of wells and boreholes. Data collected during the Phase II RFI/RI alluvial and bedrock sampling efforts may provide some indication of the reliability of previously obtained unvalidated data.

The objectives of the bedrock component of the Phase II RFI/RI are to sufficiently characterize the bedrock to support the baseline risk assessment and, if significant contamination is found, to sufficiently characterize the nature and extent of bedrock contamination to support the feasibility study, further risk assessment, and, if necessary, remedial design. A phased approach is required both for hydrogeologic characterization and

to characterize the nature and extent of contamination. At this time it is not known definitely whether or not contamination of the relatively deep unweathered bedrock exists.

This Phase II RFI/RI Bedrock Work Plan proposes 20 clusters of boreholes and wells that contain a total of 20 boreholes and 38 wells. The work plan includes a field sampling plan (FSP) that establishes the scope and criteria that will be used to redirect and expand on the sampling efforts as necessary to accomplish the stated goals. Therefore, the 20 boreholes and 38 wells represent an initial boring and sampling program that will be expanded throughout the course of the RFI/RI. The requirements for the additional sampling will depend on the interim results.

This document presents the Work Plan for the bedrock component of the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI)/ Remedial Investigation (RI) of the 903 Pad, Mound, and East Trenches areas (Operable Unit 2) at the Rocky Flats Plant, Jefferson County, Colorado. A previously prepared Alluvial Phase II RFI/RI Work Plan addresses characterization and the nature and extent of contamination of soils and groundwaters above the bottom of the upper hydrostratigraphic unit (HSU). This work plan addresses characterization and the nature and extent of contamination in the bedrock and confined water-bearing zones beneath the upper (alluvial) HSU. Potential sources of bedrock contamination are present in the upper HSU. It is not yet known whether or not the lower HSU(s) has been contaminated by the upper HSU. The data obtained during the "Alluvial" and "Bedrock" components of the RFI/RI field work will be combined and presented in a single RFI/RI report. That report will be the basis for the Corrective Measures Study/Feasibility Study (CMS/FS) and the baseline risk assessment.

The purpose of this Phase II Bedrock RFI/RI Work Plan is to define the scope of work required to characterize the geologic and hydrologic conditions within the lower HSU of the Operable Unit 2 area. This investigation is part of a comprehensive, phased program of site characterization, remedial investigations, feasibility studies, and remedial/corrective actions currently in progress at the Rocky Flats Plant. These investigations are pursuant to the U.S. Department of Energy (DOE) Environmental Restoration (ER) Program [formerly known as the Comprehensive Environmental Assessment and Response Program (CEARP)], a Compliance Agreement between DOE, the U.S. Environmental Protection Agency (EPA), and the State of Colorado Department of Health (CDH) dated July 31, 1986, and a draft Inter-Agency Agreement (IAG) being developed among DOE, EPA, and CDH. The program developed by DOE, EPA, and CDH in response to the agreements addresses RCRA and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) issues and has been integrated with the ER Program. In accordance with the draft IAG, the CERCLA terms "Remedial Investigation" and "Feasibility Study" in this document are considered equivalent to the RCRA terms "RCRA Facility Investigation" and "Corrective Measures Study" (CMS).

1.1 ENVIRONMENTAL RESTORATION PROGRAM

The ER Program is designed to investigate and clean up contaminated sites at DOE facilities. The ER Program being implemented is organized into five major activities. The first activity, Installation Assessment, includes preliminary assessments and site inspections to assess potential environmental concerns. The second activity, Remedial Investigations, includes planning and implementation of sampling programs to delineate the magnitude and extent of contamination at specific sites and evaluate potential contaminant migration pathways. Feasibility Studies, the third major activity, evaluates remedial alternatives, and develop

remedial action plans to mitigate environmental problems identified as needing correction during the remedial investigations. The fourth activity, Remedial Design/Remedial Action, includes design and implementation of site-specific remedial actions selected on the basis of the feasibility studies. Finally, Compliance and Verification implements monitoring and performance assessments of remedial actions and verifies and documents the adequacy of remedial actions carried out. Installation assessment has already been completed at the Rocky Flats Plant (DOE 1986), and remedial investigations, feasibility studies, and remedial design/remedial action are currently in progress for Operable Unit 2 (903 Pad, Mound, and East Trenches areas).

With respect to RI activities at Operable Unit 2, an initial (Phase I) field program was completed during 1987, and a draft Phase I RI report was submitted to EPA and CDH on December 31, 1987 (Rockwell International 1987a). A Phase II RFI/RI Work Plan that presents site-specific plans for further field work to characterize sources and the extent of groundwater contamination in the upper HSU (surficial materials and subcropping sandstones) was being finalized at the time of the preparation of this work plan. It is based on results presented in the draft Phase I RI report as well as subsequent groundwater sampling and analysis. This Phase II RFI/RI Bedrock Work Plan is based primarily on data presented in the Phase II RFI/RI Alluvial Work Plan, the result of recent and ongoing geologic characterization studies and resulting sampling and analysis data. An interim remedial action is being planned to treat contaminated surface water in South Walnut Creek north of Operable Unit 2. Remedial action measures will be proposed in the final RFI/RI report.

Results of the Phase I RI indicate that a complex bedrock geologic system exists beneath the 903 Pad, Mound, and East Trenches areas. A draft Geologic Characterization Report (EG&G 1990a) for the Rocky Flats Plant has been prepared based on consistent re-evaluation of borehole log data and other geologic information. That report contains a revised working model of the bedrock geology. In order to further characterize the location, extent, and orientation of sandstones, and bedrock facies and stratigraphic relationships, high-resolution seismic reflection profiling was conducted at Operable Unit 2 (EG&G 1990b). This bedrock work plan combines the information presented in the Geologic characterization report with the results of the seismic reflection work to further refine the working model of the bedrock geology.

1.2 WORK PLAN SCOPE

The previous Phase II Alluvial RFI/RI Work Plan for the 903 Pad, Mound, and East Trenches areas presented results of the Phase I RI; defined data quality objectives (DQOs) and data needs based on that investigation; specified RI tasks; and presented a Field Sampling Plan (FSP) for characterization of the upper hydrostratigraphic unit (HSU), which consists of the alluvium and hydrologically connected bedrock. This Phase II Bedrock RFI/RI Work Plan (Bedrock) includes the same basic components described above so that the two work plans may be integrated. Much of the regional and Plant site background information and site locations and descriptions are excerpted from the Alluvial Work Plan. The descriptions of the

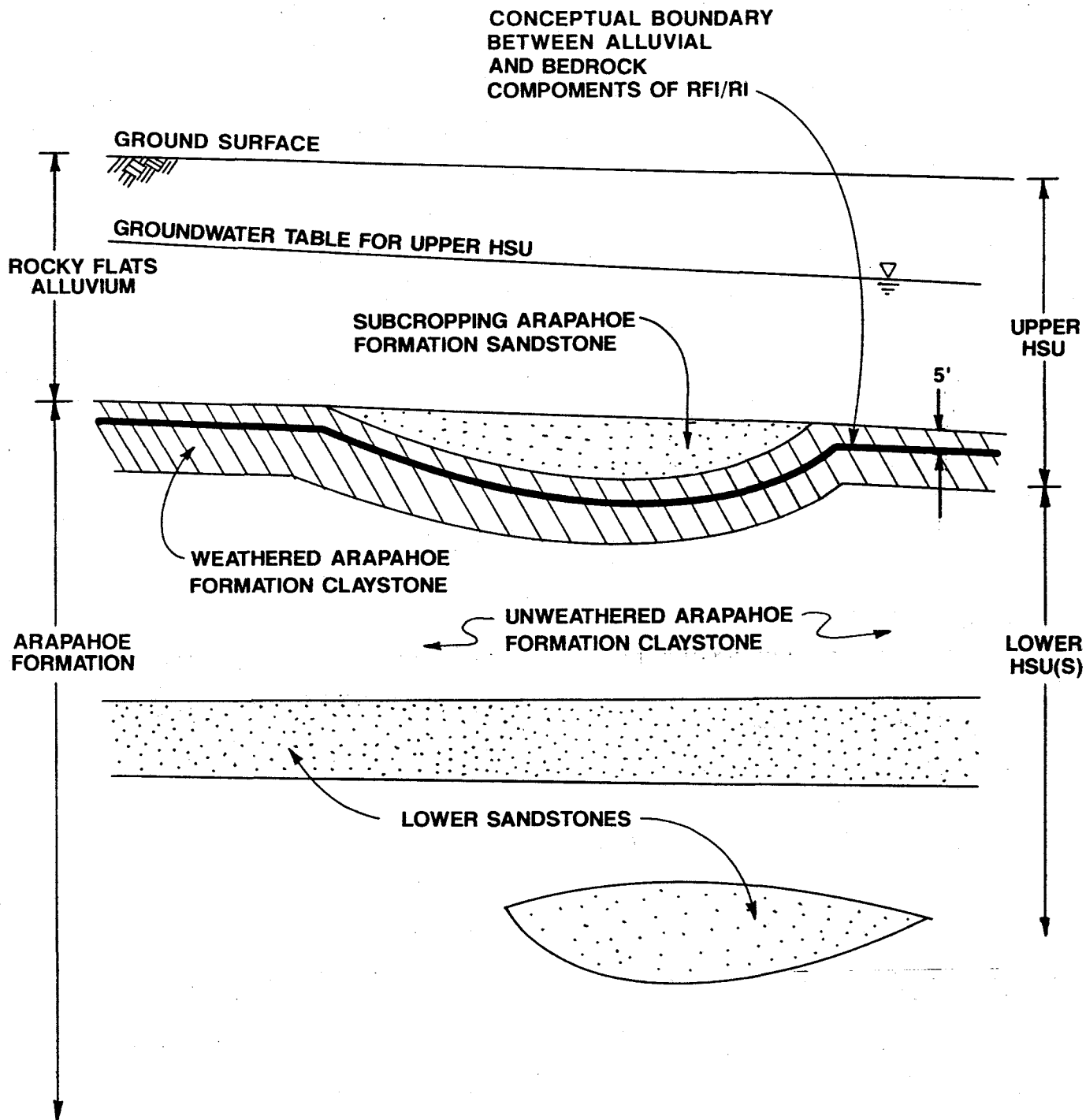
physical characteristics of and nature and extent of contamination in the upper HSU are also from the Alluvial Work Plan.

This bedrock work plan emphasizes the development of a conceptual model to describe the bedrock hydrogeology; nature and extent of contamination in the bedrock; release mechanisms, exposure pathways, and receptors; and presents a field sampling plan (FSP) that will support the baseline risk assessment. Data were compiled from a number of sources. The following previous and ongoing studies and other information were the primary sources used in preparing this work plan (a list of references is presented in Section 11.0).

- Draft Geologic Characterization Report (EG&G 1990a)
- Draft Task 3 Shallow, High-Resolution Seismic Reflection Profiling in the Medium Priority Sites (Operating (sic) Unit 2) at the Rocky Flats Plant (EG&G 1990b)
- Ongoing geologic characterization (to supplement the two studies referenced above)
- Phase II RFI/RIFS Work Plan for the 903 Pad, Mound, and East Trenches Areas (EG&G 1990c)
- Recent Rocky Flats groundwater chemistry data from RFEDS database

As part of the preparation of this work plan, the working physical model of the bedrock geology was refined by combining the geologic information presented in the three reports listed above. The bedrock hydrology and nature and extent of contamination were evaluated using data from the Phase II Alluvial RFI/RI Work Plan and subsequent analytical and groundwater data.

Figure 1-1 depicts the conceptual boundary between the alluvial and bedrock components of the RFI/RI. Subcropping sandstones have more in common with the overlying alluvial soils than with the underlying claystones and confined sandstones. For the purpose of developing work plan scopes, the boundary will be considered to occur 5 feet below the surface of the weathered claystone. This boundary is based on the vertical extent of investigation that has been selected for the alluvial component of the RFI/RI. There will be some overlap between the two components of the RFI/RI. However, considering the above, characterization of the alluvial soils and subcropping sandstones will be completed by the Alluvial RFI/RI. Overlap will occur in the weathered claystones, where lower sandstones subcrop, and where contamination sources are located within these contiguous and overlapping areas.



NOTE: HSU = HYDROSTRATIGRAPHIC UNIT

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Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

CONCEPTUAL BOUNDARY
BETWEEN
ALLUVIAL AND BEDROCK
COMPONENTS OF RFI/RI

FIGURE 1-1

1/24/91

Section 1.0 of this work plan presents introductory information and a general characterization of the region and Plant site. Descriptions of site locations and histories and prior site characterization activities are also presented in Section 1.0. Section 2.0 presents detailed descriptions of the site physical characteristics and nature and extent of contamination, culminating in a site conceptual model that is the basis for establishing data needs, data quality objectives (DQOs) and developing a FSP. Section 3.0 presents applicable or relevant and appropriate requirements (ARARs) developed for Operable Unit 2. Section 4.0 establishes data needs and DQOs considering the site characterization and the conceptual model. Sections 5.0 and 6.0 summarize RFI/RI tasks and Feasibility Study (FS) tasks, respectively. This Bedrock RFI/RI Work Plan only briefly addresses some of these tasks, such as Baseline Risk Assessment, treatability studies, alternatives development, and screening and analysis, since the Alluvial RFI/RI presents more detailed discussions of them. Section 7.0 presents a schedule for conducting the RFI/RIFS process. A Field Sampling Plan (FSP) is presented in Section 8.0 to satisfy the data needs and DQOs identified in Section 4.0. A Quality Assurance Addendum (QAA) and Standard Operating Procedure Addenda (SOPA) are presented in Sections 9.0 and 10.0, respectively.

The geologic characterization documentation used is not included in the appendix because both the Geologic Characterization Report and the High Resolution Seismic Reflection Profiling Report are in draft form and both present results on large color plates, some with transparent overlays. These reports are available for review at EG&G Rocky Flats. Soil, bedrock, and groundwater analytical chemistry data are presented in appendices to the Alluvial Work Plan. More recent bedrock groundwater chemistry data and bedrock analytical chemistry data are presented in Section 2.0 of this work plan.

1.3 REGIONAL AND PLANT SITE BACKGROUND INFORMATION

1.3.1 Background

The Rocky Flats Plant is a government-owned, contractor-operated facility that is part of the nationwide nuclear weapons production complex. The Plant was operated for the U.S. Atomic Energy Commission (AEC) from its inception in 1951 until the AEC was dissolved in January 1975. At that time, responsibility for the Plant was assigned to the Energy Research and Development Administration (ERDA), which was succeeded by the DOE in 1977. Dow Chemical U.S.A., an operating unit of the Dow Chemical Company, was the prime operating contractor of the facility from 1951 until June 1975. Rockwell International was the prime contractor responsible for operating the Rocky Flats Plant from July 1, 1975 until December 31, 1989. EG&G, Rocky Flats, Inc. became the prime contractor at the Rocky Flats Plant on January 1, 1990.

1.3.1.1 Plant Operations

The primary mission of the Rocky Flats Plant is to fabricate nuclear weapon components from plutonium, uranium, and other non-radioactive metals (principally beryllium and stainless steel). Parts made at the

Plant are shipped elsewhere for assembly. In addition, the Plant reprocesses components after they are removed from obsolete weapons for recovery of plutonium.

Both radioactive and non-radioactive wastes are generated in the production process. Current waste-handling practices involve onsite and offsite recycling of hazardous materials, onsite storage of hazardous and radioactive mixed wastes, and offsite disposal of solid radioactive materials at another DOE facility. However, both storage and disposal of hazardous, radioactive, and radioactive mixed wastes occurred on site in the past. Preliminary assessments under the ER Program identified some of the past onsite storage and disposal locations as potential sources of environmental contamination.

1.3.1.2 Previous Investigations

Various studies have been conducted at the Rocky Flats facility to characterize environmental media and to assess the extent of radiological and chemical contaminant releases to the environment. The investigations performed prior to and during 1986 are summarized in Rockwell International (1986a) and include:

- Detailed descriptions of the regional geology (Malde 1955; Spencer 1961; Scott 1960, 1963, 1970, 1972, and 1975; Van Horn 1972 and 1976; DOE 1980; Dames and Moore 1981; and Robson et al. 1981a and 1981b)
- Several drilling programs beginning in 1960 that resulted in the construction of 56 monitor wells prior to 1986
- An investigation of surface and groundwater flow systems by the U.S. Geological Survey (Hurr 1976)
- Environmental, ecological, and public health studies that culminated in an environmental impact statement (DOE 1980)
- A summary report on groundwater hydrology using data from 1960 to 1985 (Hydro-Search, Inc. 1985)
- A preliminary electromagnetic survey of the Plant perimeter (Hydro-Search, Inc. 1986)
- A soil gas survey of the Plant perimeter and buffer zone (Tracer Research, Inc. 1986)

Other investigations since 1986 include:

- Routine environmental monitoring programs addressing air, surface water, groundwater, and soils (Rockwell International 1975 through 1985, 1986b, 1987b, and 1989b)
- Background Geochemical Characterization Report (Rockwell International 1989e)

In 1986, two major investigations were completed at the Plant. The first was the ER Program Phase 1 installation assessment (DOE 1986), which included analyses and identification of current operational activities, active and inactive waste sites, current and past waste management practices, and potential environmental pathways through which contaminants could be transported. A number of sites were identified that could potentially have adverse impacts on the environment. These sites were designated as Solid Waste Management Units (SWMUs) more recently renamed Individual Hazardous Substance Sites (IHSSs) by Rockwell International (1987c) and were divided into three categories:

1. Hazardous waste management units that will continue to operate and need a RCRA operating permit.
2. Hazardous waste management units that will be closed under RCRA interim status.
3. Inactive waste management units that will be investigated and cleaned up under Section 3004(u) of RCRA or under CERCLA. No RCRA or CERCLA regulatory distinction in the use of the terms "site," "unit," "SWMU," or "IHSS" is intended in this document.

The second major investigation completed at the Plant in 1986 involved a hydrogeologic and hydrochemical characterization of the entire Plant site. Plans for this study were presented in Rockwell International publications 1986c and 1986d, and study results were reported in Rockwell International publication 1986e. Investigation results indicated four areas were significant contributors to environmental contamination, with each area containing several sites. The areas are the 881 Hillside Area, the 903 Pad Area, the Mound Area, and the East Trenches Area.

Due to their proximity, the 903 Pad, Mound, and East Trenches areas were grouped together and designated Operable Unit 2. A Phase I RI of Operable Unit 2 was completed in December 1987 (Rockwell International 1987a), and a draft Phase II RI Sampling Plan was submitted to the EPA and CDH in June 1988 (Rockwell International 1988a). A draft final Phase II RI/FS Work Plan (Alluvial) was submitted to the EPA and CDH in December 1989 (Rockwell International 1989c), and a final (Revision 0) of that document incorporating agency comments on both draft plans was issued April 12, 1990 (EG&G 1990e). EPA and CDH have granted conditional approval to the Alluvial Work Plan.

1.3.2 Physical Setting

The Rocky Flats Plant is located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver (Figure 1-2). Other surrounding cities include Boulder, Westminster, and Arvada, which are located less than ten miles to the northwest, east, and southeast, respectively. The Plant consists of approximately 6,550 acres of federally owned land in Sections 1 through 4 and 9 through 15 of T2S, R70W, 6th Principal Meridian. Major buildings are located within a Plant security area of approximately 400 acres. The security area is surrounded by a buffer zone of approximately 6,150 acres (Figure 1-3).

1.3.2.1 Topography

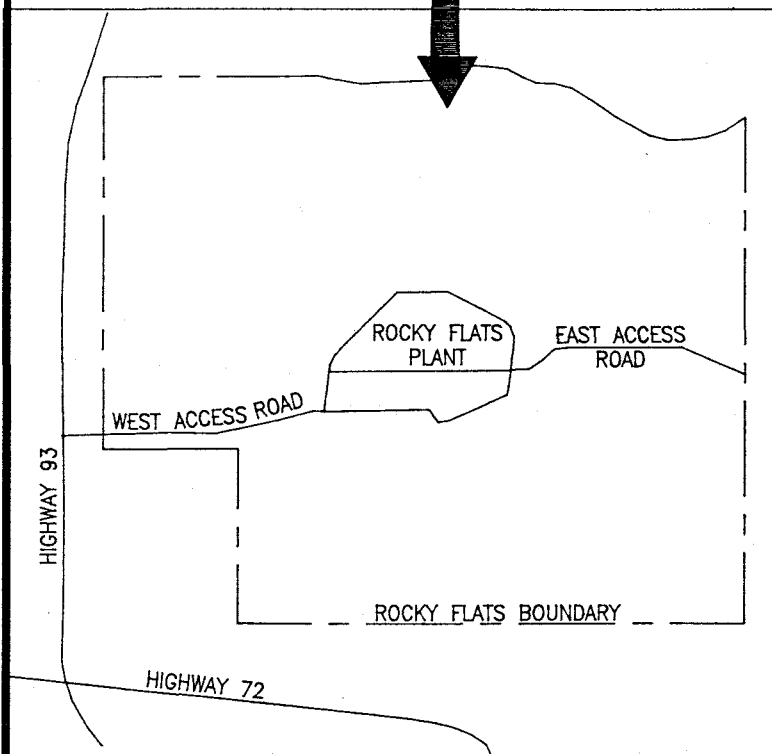
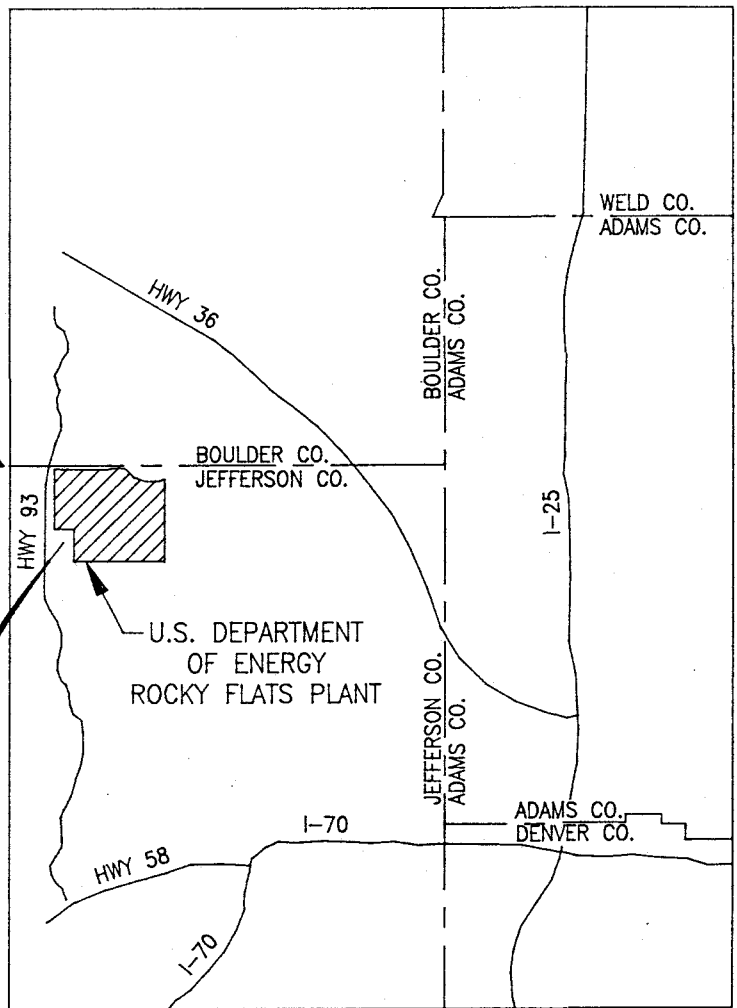
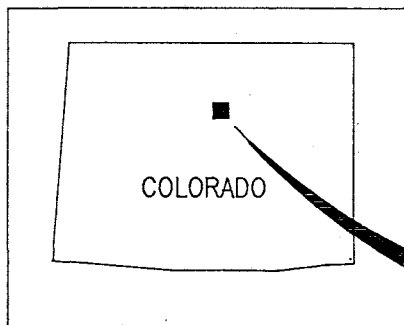
The natural environment of the Plant and vicinity is influenced primarily by its proximity to the Front Range of the Rocky Mountains. The Plant is directly east of the north-south trending Front Range, located about 16 miles east of the Continental Divide. Rocky Flats Plant is located on a broad, eastward-sloping system of coalescing alluvial fans at an elevation of approximately 6,000 feet above mean sea level (MSL). The fans extend about five miles east of the Front Range. The Main Plant Complex area is located near the eastern edge of the fans on a pediment between stream-cut gullies or arroyos (North Walnut Creek and Woman Creek).

1.3.2.2 Surface Water Hydrology

Three intermittent streams drain the Rocky Flats Plant with flow generally from west to east. These drainages are Rock Creek, Walnut Creek, and Woman Creek (Figure 1-3). Rock Creek drains the northwestern corner of the Plant and flows northeast through the buffer zone to its offsite confluence with Coal Creek. An east-west trending interfluvial separates the Walnut Creek and Woman Creek drainages. North Walnut Creek, South Walnut Creek, and an unnamed tributary drain the northern portion of the Plant security area. These three forks of Walnut Creek join in the buffer zone and flow to Great Western Reservoir, approximately one mile east of the confluence. Woman Creek drains the southern Rocky Flats Plant buffer zone, flowing eastward to Standley Reservoir. The South Interceptor Ditch lies between the Plant and Woman Creek. The South Interceptor Ditch collects runoff from the southern Plant security area and diverts it to Pond C-2, where it is monitored in accordance with the Plant's National Pollutant Discharge Elimination System (NPDES) permit prior to discharge to Woman Creek.

1.3.2.3 Regional and Local Hydrogeology

The stratigraphic section that pertains to Rocky Flats Plant includes, in descending order, unconsolidated surficial units (Rocky Flats Alluvium, various other alluvial deposits, valley fill alluvium, and colluvium), the Arapahoe Formation, the Laramie Formation, and Fox Hills Sandstone. Figure 1-4 presents a generalized stratigraphic section of the Denver Basin bedrock, and Figure 1-5 shows a generalized stratigraphic section

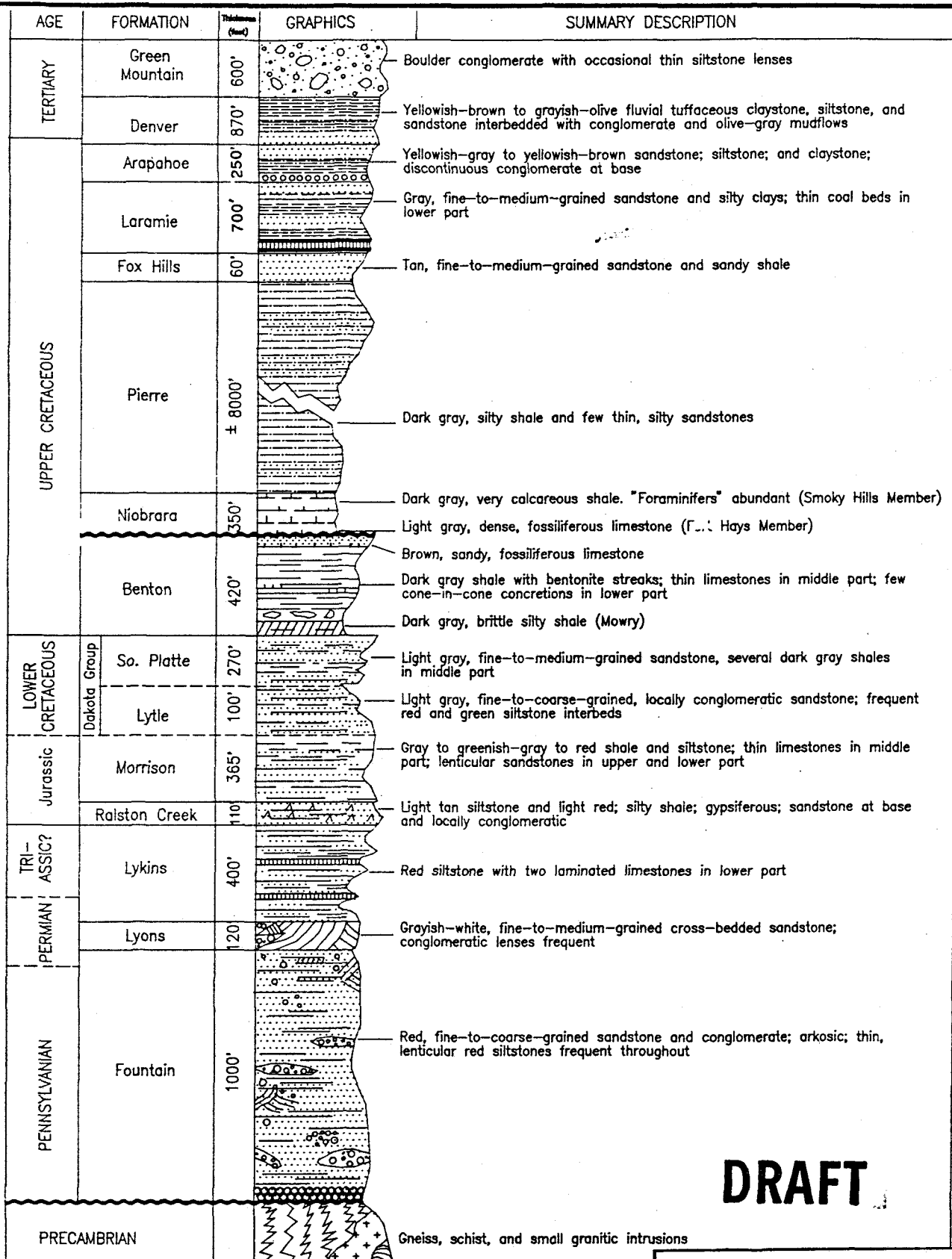


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Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

LOCATION OF ROCKY FLATS PLANT

FIGURE 1-2

January, 1991



(modified from: LeRoy and Weimer, 1971)

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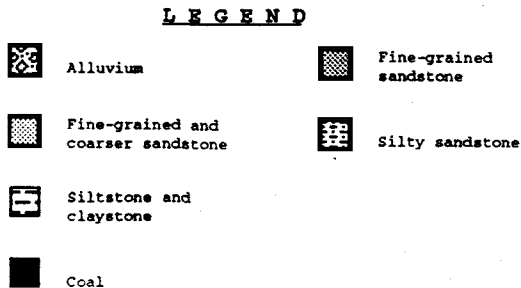
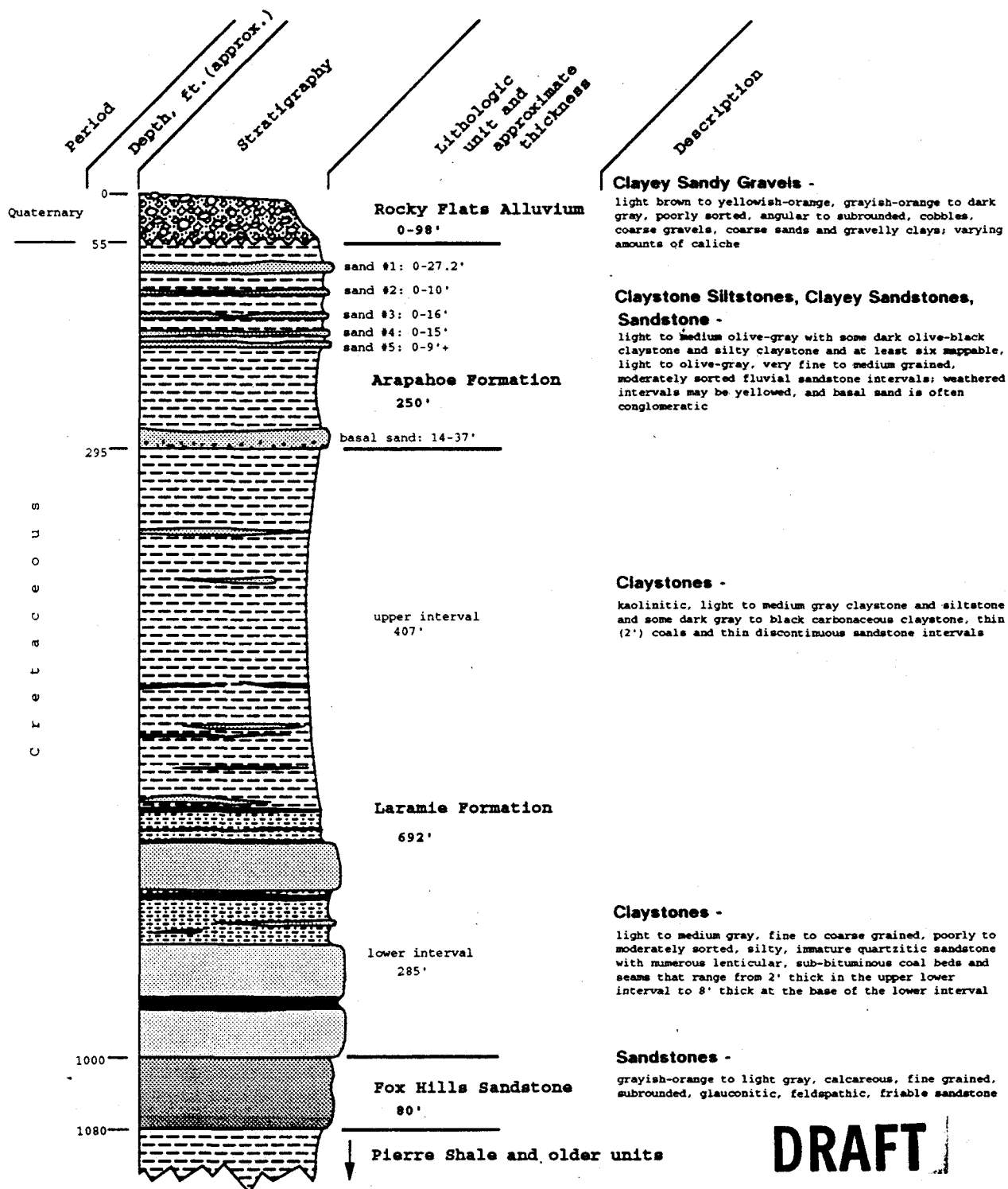
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

GENERALIZED STRATIGRAPHIC SECTION
OF THE DENVER BASIN BEDROCK

SOURCE: EG&G 1990c

FIGURE 1-4

1/24/91



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PHASE II RFI/RI WORK PLAN (BEDROCK)

LOCAL STRATIGRAPHIC SECTION
OF THE ROCKY FLATS PLANT

FIGURE 1-5

EG&G, 1991b

January, 1991

of the Rocky Flats Plant, including unconsolidated deposits. Figure 1-6 depicts the erosional surfaces of alluvial deposits east of the Front Range, Colorado. Groundwater occurs under unconfined conditions in both the surficial and shallow bedrock units. In addition, confined groundwater flow occurs in deeper bedrock sandstones (e.g., Fox Hills Sandstone).

Rocky Flats Alluvium

The Rocky Flats Alluvium underlies a large portion of the Plant. The alluvium is a broad deposit consisting of a topsoil layer underlain by up to 100 feet of varying amounts of silt, clay, sand, and gravel. Unconfined groundwater flow occurs in the Rocky Flats Alluvium, which is relatively permeable. Recharge to the alluvium is from precipitation, snowmelt, and water losses from ditches, streams, and ponds that are cut into the alluvium. General water movement in the Rocky Flats Alluvium is from west to east and toward the drainages. Groundwater flow is also controlled by pediment drainages in the top of bedrock. Groundwater levels in the Rocky Flats Alluvium rise in response to recharge during the spring and decline during the remainder of the year. Discharge from the alluvium occurs at seeps in the colluvium that covers the contact between the alluvium and bedrock along the edges of the valleys. Most seeps flow intermittently. The Rocky Flats Alluvium thins and discontinues east of the Plant boundary. It does not directly supply water to wells located downgradient of the Rocky Flats Plant.

Other Alluvial Deposits

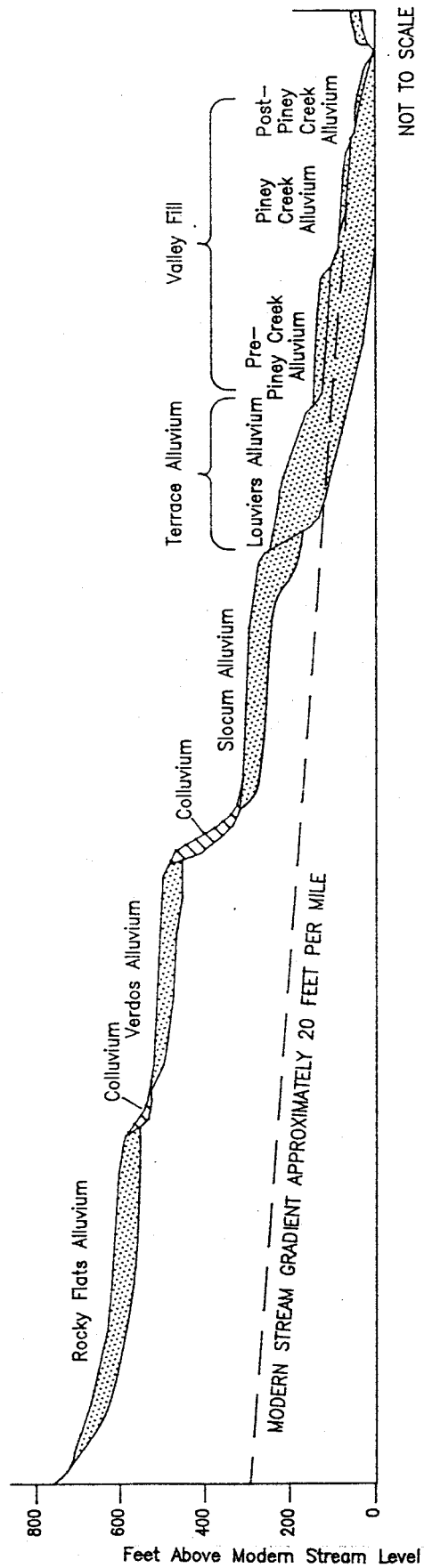
Various other alluvial deposits occur topographically below and east of the Rocky Flats Alluvium in the Plant drainages. Colluvium (slope wash) mantles the valley side slopes between the Rocky Flats Alluvium and the valley bottoms. In addition, remnants of younger terrace deposits, including the Verdos, Slocum, and Louviers alluvial deposits, occur occasionally along the valley side slopes. Recent valley fill alluvium occurs in the active stream channels.

Unconfined groundwater flow occurs in these surficial deposits. Recharge occurs through precipitation, infiltration from streams during periods of surface water runoff, and by seeps discharging from the Rocky Flats Alluvium. Discharge occurs through evapotranspiration and by seepage into other geologic formations, subcrops, and streams. The direction of groundwater flow is generally easterly and downslope through colluvial materials and then along the course of the stream in valley fill materials. During the relatively short periods of high surface water flow that periodically occur, some water is lost to bank storage in the valley fill alluvium and then returns to the stream after the runoff subsides.

EAST

WEST

ROCKY FLATS PLANT SITE



NOT TO SCALE

(after: Scott, 1960)

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OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

**EROSIONAL SURFACES AND ALLUVIAL
DEPOSITS EAST OF THE
FRONT RANGE, COLORADO**

SOURCE: EG&G 1990c

FIGURE 1-6

1/16/91

Arapahoe Formation

The Arapahoe Formation underlies surficial materials beneath the Plant. This formation is a fluvial deposit composed of overbank and channel deposits. It consists primarily of siltstones and claystones, with some silty sandstones beneath the Plant. Geologic characterization of the Arapahoe Formation beneath Rocky Flats indicates sandstones occur in stream channel-shaped structures. Total formation thickness varies up to a maximum of 270 feet (Robson et al. 1981a), and the unit is nearly horizontal beneath the Plant (less than two degree dip) (EG&G 1990a and 1990b). The channel sandstones within the claystone are composed of predominantly fine-grained sands and silts, and their hydraulic conductivity is equivalent to or less than that of the overlying Rocky Flats Alluvium. The Arapahoe Formation described by the earlier RFI/RI studies contains more clay and silt than typically described for other areas within the Denver Basin. There is a remarkable similarity of the siltstones and claystones beneath Rocky Flats to those of the Laramie Formation.

The Arapahoe Formation is recharged by groundwater from overlying surficial deposits and infiltration from streams. The main recharge areas are under the Rocky Flats Alluvium, although limited recharge from the colluvium and valley fill alluvium likely occurs along the stream valleys. Recharge is greatest during the spring and early summer, when rainfall and stream flow are at a maximum and water levels in the Rocky Flats Alluvium are high. Groundwater movement in the Arapahoe Formation is generally toward the east, although the groundwater flow regime in the bedrock has generally not yet been characterized. Regionally, groundwater flow in the Arapahoe formation is toward the South Platte River in the center of the Denver Basin (Robson et al. 1981a).

Laramie Formation and Fox Hills Sandstone

The Laramie Formation underlies the Arapahoe Formation and is composed of two units: a thick upper claystone and a lower sandstone. The claystone is greater than 700 feet thick and is of very low hydraulic conductivity; therefore, the U.S. Geologic Survey (Hurr 1976) concluded that Plant operations will not impact any units below the upper claystone unit of the Laramie Formation.

The lower unit of the Laramie Formation and the underlying Fox Hills Sandstone form a regionally important aquifer in the Denver Basin known as the Laramie-Fox Hills Aquifer. Near the center of the basin, the aquifer thickness ranges from 200 to 300 feet. These units subcrop west of the Plant and can be seen in clay pits excavated through the Rocky Flats Alluvium. The steeply dipping beds of these units west of the Plant (approximately a 50° dip) quickly flatten to the east (less than 2° dip) (EG&G 1990a, and 1990b). Recharge to the aquifer occurs along the rather limited outcrop area exposed to surface water flow and infiltration along the Front Range (Robson et al. 1981b).

1.3.2.4 Meteorology

The area surrounding the Rocky Flats Plant has a semiarid climate characteristic of much of the central Rocky Mountain region. Approximately 40 percent of the 15-inch annual precipitation falls during the spring season, much of it as wet snow. Thunderstorms (June to August) account for an additional 30 percent of the annual precipitation. Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively. Snowfall averages 85 inches per year, falling from October through May (DOE 1980).

Special attention has been focused on dispersion meteorology surrounding the Plant due to the potential for significant atmospheric releases of contaminants affecting the Denver metropolitan area. Studies of air flow and dispersion characteristics (e.g., Hodgins 1983 and 1984) indicate that drainage flows (winds coming down off the mountains to the west) turn and move toward the north and northeast along the South Platte River valley and pass to the west and north of Brighton, Colorado (DOE 1986).

1.3.3 Surrounding Land Use and Population Density

The Rocky Flats Plant is located in a rural area. Approximately 50 percent of the area within 10 miles of the Rocky Flats Plant is in Jefferson County. The remainder is located in Boulder County (40 percent) and Adams County (10 percent). According to the 1973 Colorado Land Use Map, 75 percent of this land was unused or was used for agriculture. Since that time, portions of this land have been converted to housing, with several new housing subdivisions being started within a few miles of the buffer zone.

A recent demographic study shows that approximately 2.2 million people live within 50 miles of the Rocky Flats Plant in 1989 (DOE 1990). Approximately 9,100 people lived within five miles of the Plant in 1989 (DOE 1990). The most populous sector was to the southeast, toward the center of Denver. Recent population estimates, registered by the Denver Regional Council of Governments (DRCOG), for the eight-county Denver metro region have shown distinct patterns of growth between the first and second halves of the 1980s. Between 1980 and 1985, the population of the eight-county region increased by 197,890, a 2.4 percent annual growth rate. Between 1985 and 1989, a population gain of 71,575 was recorded, representing a 1.0 percent annual increase (the national average). The 1989 population showed an increase of 2,225 (or 0.1 percent) from the same date in 1988 (DRCOG 1989).

There are 8 public schools within 6 miles of the Rocky Flats Plant. The nearest educational facility is the Witt Elementary School, which is approximately 2.7 miles east of the Plant buffer zone. The closest hospital is Centennial Peaks Hospital, located approximately 7 miles northeast. The closest park and recreational area is the Standley Lake area, which is approximately 5 miles southeast of the Plant. Boating, picnicking, and limited overnight camping are permitted. Several other small parks exist in communities within 10 miles. The closest major park, Golden Gate Canyon State Park, located approximately 15 miles to the southwest,

provides 8,400 acres of general camping and outdoor recreation. Other national and state parks are located in the mountains west of the Rocky Flats Plant, but all are more than 15 miles away.

Some of the land adjacent to the Plant is zoned for industrial development. Industrial facilities within 5 miles include the TOSCO laboratory (a 40-acre site located 2 miles south), the Great Western Inorganics Plant (2 miles south), the Frontier Forest Products yard (2 miles south), the Idealite Lightweight Aggregate Plant (2.4 miles northwest), and the Jefferson County Airport and Industrial Park (a 990-acre site located 4.8 miles northeast).

Several ranches are located within 10 miles of the Plant, primarily in Jefferson and Boulder Counties. They are operated to produce crops, raise beef cattle, supply milk, and breed and train horses. According to the 1987 Colorado Agricultural Statistics, 20,758 acres of crops were planted in Jefferson County (total land area of approximately 475,000 acres) and 68,760 acres of crops were planted in Boulder County (total land area of 405,760 acres). Crops consisted of winter wheat, corn, barley, dry beans, sugar beets, hay, and oats. Livestock consisted of 5,314 head of cattle, 113 hogs, and 346 sheep in Jefferson County, and 19,578 head of cattle, 2,216 hogs, and 12,133 sheep in Boulder County (Post, 1989).

1.3.4 Ecology

A variety of plant life thrives within the Plant boundary. Included are species of flora representative of tall grass prairie, short grass plains, lower montane, and foothill ravine regions. None of these species are on the endangered species list. It is evident that the vegetative cover along the Front Range of the Rocky Mountains has been radically altered by human activities such as burning, timber cutting, road building, and overgrazing for many years. Since the acquisition of the Rocky Flats Plant property, vegetative recovery has occurred, as evidenced by the presence of disturbance-sensitive grass species such as big bluestem (*Andropogon gerardii*) and sideoats grama (*Bouteloua curtipendula*). No vegetative stresses attributable to hazardous waste contamination have been identified (DOE 1980).

The animal life inhabiting the Rocky Flats Plant and its buffer zone consists of species associated with western prairie regions. The most common large mammal is the mule deer (*Odocoileus lemionus*), with an estimated 100 to 125 permanent residents. There are a number of small carnivores, such as the coyote (*Canis latrans*), red fox (*Vulpes fulva*), striped skunk (*Mephitis mephitis*), and long-tailed weasel (*Mustela frenata*). A profusion of small herbivores can be found throughout the Plant and buffer zone, species such as the pocket gopher (*Thomomys* sp.), white-tailed jackrabbit (*Lepus tounsedii*), and the meadow vole (*Microtus pennsylvanicus*) (DOE 1980).

Commonly observed birds include western meadowlarks (*Sturnella neglecta*), horned larks (*Eremophila alpestris*), mourning doves (*Zenaidura macroura*), and vesper sparrow (*Pooecetes gramineus*). A variety of ducks, killdeer (*Charadrius vociferus*), and red-winged black birds (*Agelaius phoeniceus*) are seen in areas

adjacent to ponds. Mallards (*Anas platyrhynchos*) and other ducks (*Anas* sp.) frequently nest and rear young on several of the ponds. Common birds of prey in the area include marsh hawks (*Circus cyaneus*), red-tailed hawks (*Buteo jamaicensis*), ferruginous hawks (*Buteo regalis*), rough-legged hawks (*Buteo lagopus*), and great horned owls (*Bubo virginianus*) (DOE 1980).

Bull snakes (*Pituophis melanoleucus*) and rattlesnakes (*Crotalus* sp.) are the most frequently observed reptiles. Eastern yellow-bellied racers (*Coluber constrictor*) have also been reported on the site, but these and other lizards are not commonly observed. The western painted turtle (*Chrysemys picta*) and the western plains garter snake (*Thamnophis radix*) are found in and around many of the ponds (DOE 1980).

1.4 SITE LOCATIONS AND DESCRIPTIONS

This Bedrock RFI/RI Work Plan addresses Operable Unit 2, which contains the 903 Pad, Mound, and East Trenches areas located on the east side of Rocky Flats security area. Several sites are included in each area. Figure 1-7 shows the locations of these areas, the sites within each area, and the operable unit boundary. Each site was assigned a SWMU reference number by Rockwell International (1987c). Since then, the SWMUs have been renamed IHSSs; however, the reference numbers are the same.

Site descriptions presented in the following sections are taken from the Rocky Flats Plant CEARP Phase 1 report (DOE 1986) and the RCRA Part B Operating Permit Application (Rockwell International 1987c), as reported in EG&G (1990c). These descriptions are based on historical records, aerial photography review, and interviews with Plant personnel. Further characterization of each site based on other historical reports is also included in the following discussions.

1.4.1 903 Pad Area

Five sites are located within the 903 Pad Area (Figure 1-7). These sites are:

- 903 Drum Storage Site (IHSS Ref. No. 112)
- 903 Lip Site (IHSS Ref. No. 155)
- Trench T-2 Site (IHSS Ref. No. 109)
- Reactive Metal Destruction Site (IHSS Ref. No. 140)
- Gas Detoxification Site (IHSS Ref. No. 183)

Descriptions of each site within the 903 Pad Area are provided in the following sections.

1.4.1.1 903 Drum Storage Site (IHSS Ref. No. 112)

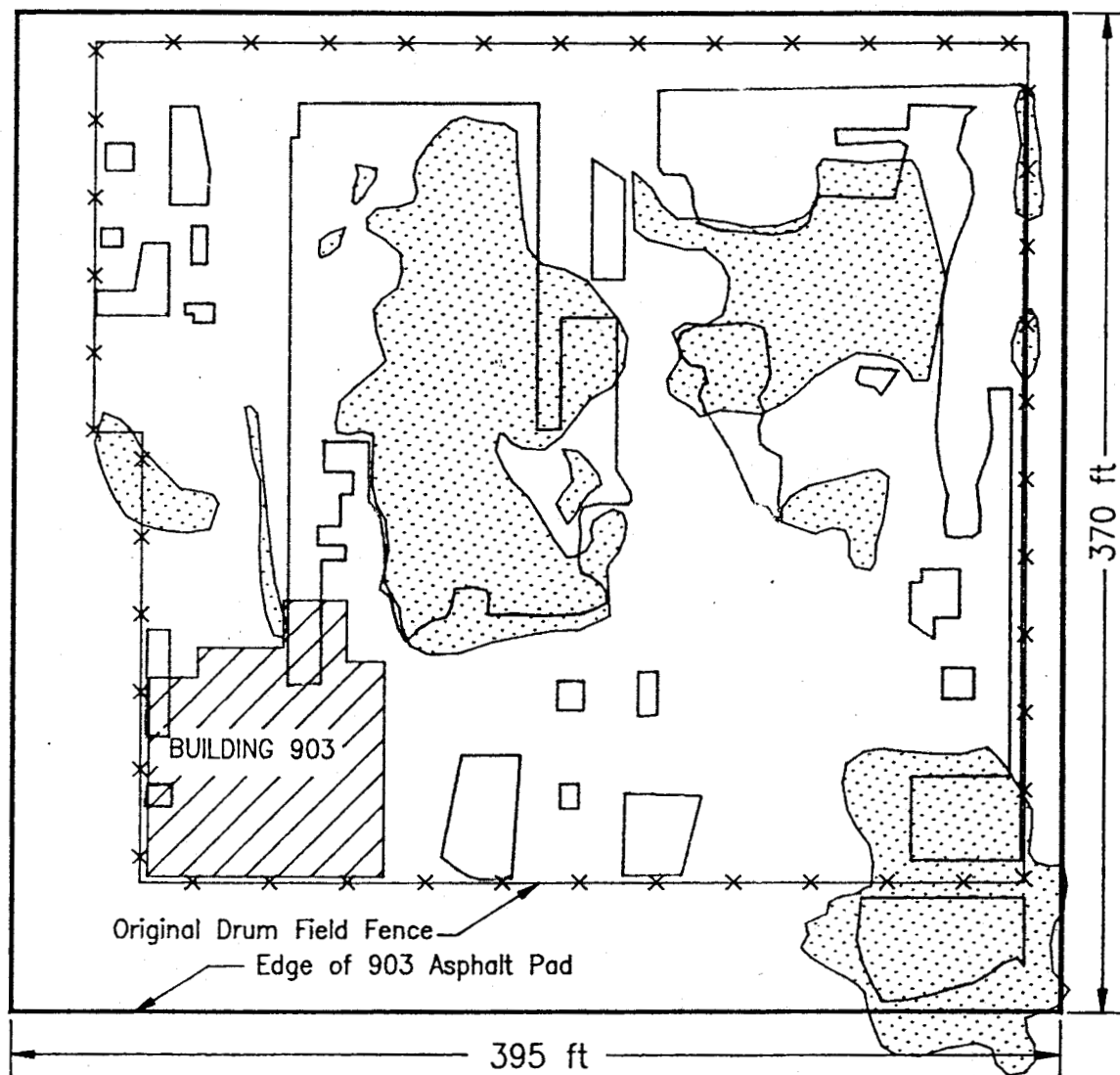
The 903 Drum Storage Site is located in the eastern portion of the Plant security zone. This area was used from October 1958 to January 1967 for storage of radioactively contaminated oil drums (Calkins 1970). Presented below is a description of drums stored at the drum storage site from Calkins (1970).

"Most of the drums transferred to the field were nominal 55-gallon drums, but a significant number were 30-gallon drums. Not all were completely full. Approximately three-fourths of the drums were plutonium-contaminated, while most of the balance contained uranium. Of those containing plutonium, most were lathe coolant consisting of a straight-chain hydrocarbon mineral oil (Sell Vitrea) and carbon tetrachloride in varying proportions. Other liquids were involved, however, including hydraulic oils, vacuum pump oil, trichloroethylene, perchloroethylene, silicone oils, acetone still bottoms, etc. Originally, contents of the drums were indicated on the outside, but these markings were made illegible through weathering and no other good records were kept of the contents. Leakage of the oil was recognized early, and in 1959 or possibly earlier ethanolamine was added to the oil to reduce the corrosion rate of the steel drums."

Drum leakage was noted at the 903 Drum Storage Site in 1964 during routine drum handling operations (Dow Chemical 1971). Corrective action consisted of transferring the contents of leaking drums to new drums and fencing the area to restrict access. Approximately 420 drums leaked to some degree, and, of these, an estimated 50 leaked their entire contents. An estimated 5,000 gallons of liquid (Freiberg 1970) containing 86 grams (g) [5.3 curies (Ci)] of plutonium leaked into the soil (Dow Chemical 1971). A heavy rainstorm in 1967 spread contaminants to a ditch south and southeast of the drum storage site (Dow Chemical 1971); however, the location of the ditch is not provided by this reference.

Figure 1-8 outlines drum locations and soil staining at the 903 Drum Storage Site based on a review of historical aerial photography. As seen on this figure, drum storage occurred primarily in the northern and eastern portions of the area. Drums were not stored in the southwest portion, where Building 903 was constructed in 1967, and were only briefly stored at the southeast corner. It appears that the drums stored south of the fenced area were placed at this location during cleanup operations, as they appear only in the 1968 aerial photos.

The shipment of drums to the 903 Drum Storage Site ended in January 1967, when drum removal efforts began. Removal of all drums and wastes was completed in June 1968.



EXPLANATION



AREA OF SOIL STAINING BASED ON AERIAL PHOTOGRAPHS FROM:
4/29/67, 4/10/68, 5/24/69.



BARREL STORAGE LOCATIONS BASED ON AERIAL PHOTOGRAPHS FROM:
5/5/63, 4/29/65, 4/29/67, 9/10/68.

NOTE: BUILDING 903 LOCATION BASED ON AERIAL PHOTOGRAPHS FROM 4/10/68.

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Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

APPROXIMATE LOCATIONS OF DRUM
STORAGE-903 PAD DRUM
STORAGE SITE

SOURCE: EG&G 1990c

FIGURE 1-8

1/24/91

Presented below is a chronology of the 903 Drum Storage Site cleanup, as described by Freiberg (1970).

- "From January 23, 1967, through March 10, 1967, uranium oil drums which were in good condition were transferred to Building 774 and processed.
- "Building 903...on March 10, 1967, started processing oil drums. This building was designated to prefilter the oil prior to transferring plutonium contaminated oil to Building 774 for final processing.
- "From March 10, 1967 through May 18, 1967, there were a total of 191 drums of plutonium contaminated oil filtered and shipped to Building 774.
- "On May 18, 1967, operations at building 903 were discontinued due to the amount of time this process was taking.
- "Drum-to-drum transfer in the field began May 18, 1967, and the drums were [SIC] shipped to Building 774 without prior filtration in Building 903.
- "From March 17, 1967 through May 10, 1967, in addition to the plutonium transfers, there were 297 drums of uranium contaminated Alk-Tri waste shipped to Building 774 and processed.
- "May 10, 1967 through May 28, 1968, a total of 4,826 drums containing 50 gallons of oil each were sent to Building 774 and processed.
- "In addition to the oil storage area drums, there were a total 650 drums from Building 776 current generation sent to Building 774 for processing. a pipeline installed from Building 776 to Building 774 eliminated this additional oil drum generation.
- "During the transfer operations, it was noted that at the bottom of all drums a deposit of sludge remained after removal of the oil. This sludge varied in depth from 1/2 inches to 3 inches and averaged approximately 1 inch. By drum counter results the sludge within the empty drums contained a total of 5,152 grams (315.8Ci) of plutonium. These empty drums were later disposed of by adding Oil Dry and MicroCel to absorb the sludge. The drums containing the plutonium sludge and absorbent were then incased in plastic, placed in boxes, and shipped to the burial grounds." [The location of the burial grounds is not provided by Freiberg (1970).

There were originally a total of 5,237 drums at the drum storage site when cleanup operations began in 1967. After transfer of the contents to new drums, 4,826 drums, of which 3,572 drums contained plutonium-contaminated oil, were transported to Building 774. This leaves the contents of 411 drums unaccounted-for. The most probable explanation for this discrepancy, according to Freiberg (1970), is a combination of the following factors:

- All of the drums originally sent to the storage site were not completely full.
- Some of the volume was taken up by the sludge that was discarded with the empty barrels.
- Leakage out of the barrels and onto the ground occurred.

Information provided by Freiberg (1970) indicates that an estimated 5,000 gallons of oil leaked from drums onto the ground at the drum storage site. This estimate was based on the memory and knowledge of those involved in site operations. Based on oil samples taken from barrels, the average plutonium concentration was 4.54×10^{-3} grams per liter (g/l) [280 pico Curies/liter (pCi/l)]. Thus, approximately 86 g (5.3 Ci) of plutonium were released to soils at the drum storage site (Freiberg 1970).

In November 1968, site grading began at the 903 Drum Storage Site in preparation for applying an asphalt cap over the area. This work included moving "slightly" contaminated soil from around the fenced area to inside the fenced area. A total of 33 drums of radioactively contaminated rocks were removed from the area to inside the fenced area (Freiberg 1970). A total of 33 drums of radioactively contaminated rocks were removed from the area in May 1969, and two courses of clean fill material were placed over the site during the late summer of 1969. The asphalt was applied in October 1969, and in February 1970 additional road base course material was applied to soils directly east and south of the asphalt pad due to soil contamination (Freiberg 1970).

The asphalt containment cover is rectangular and oriented north-south (370 feet) and east-west (395 feet). The pad dips slightly to the northeast at a drop of one foot per 100 feet. The asphalt cover is approximately 8 centimeters (cm) (3.2 inches) thick and it is underlain by approximately 15 cm (6 inches) of loose gravel and 8 cm of fill dirt (Navratil et al. 1979).

1.4.1.2 903 Lip Site (IHSS Ref. No. 155)

During drum removal and cleanup activities associated with the 903 Drum Storage Site, winds redistributed plutonium beyond the pad to the south and east. An estimated 1 Ci (16.3 g) of plutonium was redistributed beyond the asphalt pad and, of that 1 Ci, approximately 0.56 Ci (9.1 g) is believed to have been deposited in the 903 Lip Site (Barker 1982). The most contaminated area was immediately adjacent to the pad to the south and southeast. Surveys at the time showed a maximum plutonium concentration of 2,258 picoCuries

per gram (pCi/g) [5,680 disintegrations per minute per gram (dpm/g)] in the top 5 cm (2 inches) of soil at the 903 Lip Site (Barker 1982).

Soil cleanup efforts were undertaken in 1976, 1978, and 1984 to remove plutonium-contaminated soils from three different areas within the 903 Lip Site. The 1976 soil removal operation began in June 1976 and ended in September 1976. This cleanup consisted of hand-excavating contaminated soils from an area in the vicinity of the Reactive Metal Destruction Site until soil contamination levels were below the detection limit of the Field Instrument for Detection of Low Energy Radiation (FIDLER). The detection limit of the FIDLER is 250 counts per minute (cpm). The FIDLER "counts" are an instrument-dependent measure of surface activity and cannot be converted to plutonium concentration in the soil. The excavated area was covered with clean top soil and reseeded with native grasses. Thirty-five boxes, weighing a total of 125,000 pounds, were removed and shipped offsite for disposal during the 1976 cleanup (Barker 1982). The offsite disposal location was not provided by Barker (1982). Recent radiological surveys have been conducted to further assess radioactive contamination. These include an aerial gamma survey conducted in July 1989 (EG&G 1990e) and a ground-based gamma survey conducted in 1990.

The 1976 soil-removal technique of hand-excavation was inefficient, considering the large amount of contaminated soils requiring removal at the 903 Lip Site. In June 1978, a second soil removal project began north of the 1976 removal using a front-end loader alone and in conjunction with a bulldozer. All soil that exceeded 2,000 cpm, as determined by a FIDLER survey, was removed. Cleaned areas were resurveyed and soil removal continued until background-level readings (approximately 250 cpm by a FIDLER survey) were obtained. Topsoil was then applied to the excavated area, and the site was revegetated with native grasses. During the 1978 soil removal, 1448 boxes, weighing approximately 4.7 million pounds, were removed and shipped offsite (Barker 1982). The offsite disposal location was not provided by Barker (1982).

Approximately 0.5 Ci (8.2 g) of plutonium were removed from the 903 Lip Site during the two soil-removal projects. This quantity is based on an average soil plutonium concentration of 545 pCi/g (1,200 dpm/g) and a soil density of one gram per cubic centimeter (g/cm^3) (Barker 1982).

A third soil cleanup was performed along the eastern edge of the 903 Lip Site in 1984. A total of 214 tri-wall pallets of contaminated soil were removed from the area. The excavated area was backfilled with clean topsoil (Setlock 1984).

1.4.1.3 Trench T-2 Site (IHSS Ref. No. 109)

Trench T-2 is located south of the 903 Drum Storage Site and west of the Reactive Metal Destruction Site, within the 900 Area (Figure 1-6). This trench was used prior to 1968 for the disposal of sanitary sewage sludge and flattened drums contaminated with uranium and plutonium. This trench is believed to measure

approximately 15 feet wide by 200 feet long by 5 feet deep (Rockwell International 1987c). Barrels were noted in the western end of Trench T-2 during 1987 investigations.

1.4.1.4 Reactive Metal Destruction Site (IHSS Ref. No. 140)

The Reactive Metal Destruction Site is located on the hillside south of the 903 Drum Storage Site (Figure 1-6). This site was used during the 1950s and 1960s primarily for the destruction of lithium metal (DOE 1986). Approximately 400 to 500 pounds of metallic lithium were destroyed on the ground surface in this area and the residues, primarily lithium carbonate, buried (Illsley 1978). Smaller unknown quantities of sodium, calcium, magnesium, solvents, and unknown liquids were also destroyed at this location (Illsley 1978).

Based on review of historical aerial photography, the Reactive Metal Destruction Site was used from 1968 to 1971. Barrels were noted in the southwestern corner of IHSS 140 during 1987 investigations.

1.4.1.5 Gas Detoxification Site (IHSS Ref. No. 183)

Building 952, located south of the 903 Drum Storage Site, was used to detoxify various gases from lecture bottles between June 1982 and August 1983. The lecture bottles held approximately one liter of compressed gas, each. The gases consisted of various types of nitrogen oxides, chlorine, hydrogen sulfide, sulfur tetrafluoride, methane, hydrogen fluoride, and ammonia, which were used in Plant research and development work. Gas detoxification was accomplished by using various commercial neutralization processes available at the time. After neutralization, glassware used in the process was triple-rinsed, crushed, and deposited in the present landfill. The neutralized gases released into the environment during detoxification would no longer be detectable (Rockwell International 1987c).

1.4.2 Mound Area

The Mound Area is composed of four sites (Figure 1-6). These are:

- Mound Site (IHSS Ref. No. 113)
- Trench T-1 Site (IHSS Ref. No. 108)
- Oil Burn Pit No. 2 Site (IHSS Ref. No. 153)
- Pallet Burn Site (IHSS Ref. No. 154)

These sites are described individually below.

1.4.2.1 Mound Site (IHSS Ref. No. 113)

The Mound Site, located north of Central Avenue in the eastern Plant security area, was used between April 1954 and September 1958 for drum disposal. Approximately 1,405 drums containing primarily depleted uranium- and beryllium-contaminated lathe coolant (a mixture of about 70 percent hydraulic oil and 30 percent carbon tetrachloride) were placed at the Mound Site (Rockwell International 1987c). [Records do not indicate that the barrels were actually buried (Calkins 1970)]. It is likely that some of the coolant also contained enriched uranium and plutonium (Rockwell International 1987c). Some drums also contained Perclene (Smith 1975): Perclene was a brand name of tetrachloroethene (Sax and Lewis 1987). Some of the drummed wastes placed in the Mound Site were in solid form (Rockwell International 1987c).

Cleanup of the Mound Site was accomplished in May 1970, and the materials removed were packaged and shipped to an offsite DOE facility for disposal. Listed below is an inventory of the 1,405 drums removed from the Mound Site in 1970 (Dow Chemical 1971).

<u>No. of Drums</u>	<u>Contents</u>
903	30-gallon drums of depleted-uranium solid waste
21	30-gallon drums of depleted-uranium oil waste
12	30-gallon drums of plutonium-contaminated oil waste. "The plutonium content was so low that it was measurable only by the most sensitive laboratory techniques" (Dow Chemical 1971).
102	55-gallon drums of depleted-uranium solid waste
282	55-gallon drums of depleted-uranium oil waste
<u>85</u>	<u>55-gallon drums of enriched-uranium oil waste</u>
1,405	TOTAL DRUMS

Subsequent surficial soil sampling in the vicinity of the excavated Mound Site indicated 0.8 to 112.5 dpm/g (0.4 to 51 pCi/g) activity. This radioactive contamination is thought to have come from the 903 Drum Storage Site via wind dispersion rather than from the Mound Site, as it was limited to the surface (Rockwell International 1987c).

1.4.2.2 Trench T-1 Site (IHSS Ref. No. 108)

The trench was used from 1954 until 1962 and contains approximately 125 drums filled with approximately 25,000 kilograms (kg) (55,115 pounds) of depleted-uranium chips (Dow Chemical 1971) and plutonium chips

coated with small amount of lathe coolant (Rockwell International 1987c). The estimated dimensions of Trench T-1 are 15 feet wide by 200 feet long by 5 feet deep (Rockwell International 1987c). Trench T-1 was covered with about two feet of soil, and the corners were marked (Rockwell International 1987c).

Weed-cutting activities in October and November 1968 unearthed two drums inadequately covered with fill material. Both drums were sampled and analyzed for total plutonium and uranium contents before they were disposed offsite (Illsley 1983). The offsite disposal location was not provided by Illsley (1983). One of the drums sampled contained an oil-water mixture with 55 pCi/l of plutonium and 2.3×10^5 pCi/l of uranium. The other drum contained an oily sludge with 4.6 pCi/g of plutonium and 1.2×10^6 pCi/g of uranium (Illsley 1983).

1.4.2.3 Oil Burn Pit No. 2 Site (IHSS Ref. No. 153)

Oil Burn Pit No. 2 is actually two parallel trenches that were used in 1957 and from 1961 to 1965 to burn approximately 1,082 drums of oil containing uranium (Rockwell International 1987c). In March and April of 1957, the contents of an estimated 169 uranium-contaminated waste oil drums were burned. No further burning took place until 1961. Frequent burning of waste oil took place from June 1961 to May 1965. The contents of approximately 914 drums were burned during this time. The drums used for the oil burning operation were generally reused; however, 300 empty drums were discarded by flattening and burying them in the burning pits (Dow Chemical 1971). The uranium concentrations of the burned waste oil is unknown. The residues from the burning operations and the flattened drums were covered with backfill. In 1978, the area was excavated to a depth of approximately 5 feet and 289 boxes (56 cubic feet per box) of contaminated soil were removed and shipped offsite to an authorized DOE disposal site (Illsley 1983). The offsite disposal location was not provided by Illsley (1983).

1.4.2.4 Pallet Burn Site (IHSS Ref. No. 154)

An area southwest of Oil Burn Pit No. 2 was reportedly used to destroy wooden pallets in 1965. The types of hazardous substances or radionuclides that may have been spilled on these pallets is unknown. This site was cleaned up and reclaimed in the 1970s (DOE 1986). Two locations for the Pallet Burn Site are shown on Figure 1-6. The westernmost location was reported by Owen and Steward (1973). However, based on review of historical aerial photographs, there was no disturbance at this western location. The eastern location was identified from 1963 and 1965 aerial photography of the area.

1.4.3 East Trenches Area

The East Trenches Area consists of nine burial trenches and two spray irrigation sites. These sites are:

- Trench T-3 (IHSS Ref. No 110)
- Trench T-4 (IHSS Ref. No. 111.1)
- Trench T-5 (IHSS Ref. No. 111.2)
- Trench T-6 (IHSS Ref. No. 111.3)
- Trench T-7 (IHSS Ref. No. 111.4)
- Trench T-8 (IHSS Ref. No. 111.5)
- Trench T-9 (IHSS Ref. No. 111.6)
- Trench T-10 (IHSS Ref. No. 111.7)
- Trench T-11 (IHSS Ref. No. 111.8)
- East Spray
- Irrigation Sites (IHSS Ref. Nos. 216.2 and 216.3)

Trenches T-3, T-4, T-10, and T-11 are located north of the east access road, and Trenches T-5 through T-9 are south of the east access road. The wastes in these trenches have not been disturbed since their burial. The spray irrigation areas are located east of Trenches T-5 through T-9 (Figure 1-6).

1.4.3.1 Trenches T-3 through T-11 (IHSS Ref. Nos. 110 and 111.1-111.8)

These trenches, as well as Trench T-2, were used from 1954 to 1968 for disposal of approximately 125,000 kg of sanitary sewage sludge contaminated with uranium and plutonium and approximately 300 flattened, empty drums contaminated with uranium (Illsley 1983). Radiation content of the sewage sludge ranged from 8.4×10^5 dpm/kg (382 pCi/g) to 7.9×10^6 dpm/kg (3,590 pCi/g) (Owen and Steward 1973). Total alpha radioactivity in Trenches T-2 through T-8 is estimated to be 100 to 150 milliCuries (0.1 to 0.14 Ci) (Dow Chemical 1971). Trenches T-4 and T-11 also contain some plutonium- and uranium-contaminated asphalt planking from the solar evaporation ponds (Illsley 1983).

According to Illsley (1983), samples were collected from Trenches T-9, T-10, and T-11, and the results were as follows:

"Samples from T-11 contained plutonium in the ranges from 4.5 to 50 pCi/g and uranium-238 in the range between 0.9 and 158 pCi/g. Trench T-10 was found to contain uranium in the range between 40 and 126 pCi/g and Pu-239 in the range from 0.18 to 14 pCi/g.... Plutonium concentrations in collected samples varied from 0.40 to 68 pCi/g and uranium was found in the range between 2.4 and 450 pCi/g in Trench T-9."

The sampling dates and collection methods of these samples are unknown.

1.4.3.2 East Spray Irrigation Sites (IHSS Ref. Nos. 216.2 and 216.3)

IHSS numbers 216.2 and 216.3 were used for spray irrigation of sewage treatment plant effluent. These areas have been designated as IHSSs because effluent containing low concentrations of chromium was inadvertently sprayed in the area in February and March 1989. The chromium entered the sanitary sewage treatment plant on February 3, 1989, subsequent to a spill of chromic acid in Building 444 (Rockwell International 1989d).

1.5 PRIOR SITE CHARACTERIZATION

Site characterization activities have been conducted at Rocky Flats over approximately the past 30 years. Drilling programs initiated in 1960 resulted in the construction of 56 groundwater monitoring wells Plant-wide prior to 1986. At least six of these pre-1986 wells are located within Operable Unit 2. Screen intervals and other construction details of these wells are unknown. The six pre-1986 wells and their depths are: Well 171, 24 feet deep; Well 271, 30 feet deep; Well 174, 24 feet deep; Well 374, 24 feet deep; Well 774, 50 feet deep; and Well 2274, 162 feet deep. Other previous activities are listed in Subsection 1.3.1.2 of this work plan. A Phase I RI was conducted in 1986 and 1987 to initiate the second major activity of the ER Program at Rocky Flats. Figure 1-9 shows the locations of boreholes drilled and monitoring wells installed in 1986 and 1987, as well as the locations of several monitoring wells installed in 1971 and 1974. Little is known about the construction details of the earlier wells. Several figures in Section 2.0 show the area where the majority of the boreholes are located at a larger scale.

1.5.1 Phase I Remedial Investigation

A Phase I RI (Rockwell International 1987a) was conducted to initiate Phase 2 of the Rocky Flats ER Program at Operable Unit 2.

The Phase I RI consisted of the following field activities:

- Electromagnetic, resistivity, and magnetometer geophysical surveys
- A soil gas survey
- Soil sample collection from 33 boreholes
- Completion of 10 Alluvial and 14 bedrock monitoring wells

- Groundwater sampling of new and previously existing wells
- Slug testing of 13 wells
- Packer testing of cored bedrock wells
- Collection of 22 surface water seep samples
- Air monitoring for total long-lived alpha, plutonium, and volatile organics during field activities

In addition to the Phase I investigation at the 903 Pad, Mound, and East Trenches areas, several monitoring wells were installed in these area as part of a Plant-wide hydrologic investigation in 1986 (Rockwell International 1986e). Surface water, soil, and air samples have also been collected at these areas as part of various investigations. The Phase II RFI/RI Work Plan (Alluvial) presents a more complete summary of the Phase I RI than this bedrock work plan does. This work plan presents data from the Phase I RI and other previous work that are pertinent to bedrock characterization. Radiological surveys of the ground surface have also been conducted, the results of which are discussed in the Alluvial Work Plan. These included a survey of the 903 Pad in 1968 and an aerial radiological survey of the entire plant (EG&G 1990e). In addition, further ground-based radiological measurements were obtained in summer/fall 1990, the results of which are not yet published.

1.5.2 Recent Geologic Characterization

Subsequent to the draft Phase I RI report, EG&G identified inconsistencies in the methods that had been used for logging geologic materials and interpreting geologic data. As a result, a project was initiated to develop a geologic characterization of the Rocky Flats Plant by conducting a literature review reclassifying previously obtained samples using standardized procedures, conducting further laboratory testing on previously obtained samples, processing seismic data, and then reinterpreting the geology based on all available data.

Interim results of this ongoing study are presented in a draft report (EG&G 1990a). That report presents summaries of stratigraphy and structural geology of the area and regions, the current working model of Plant geology, conclusions based on the working model, and recommendations for further work required to continue the ongoing characterization.

Shallow, high-resolution seismic reflection profiling (EG&G 1990b) has been conducted to supplement the ongoing geologic characterization efforts. A primary focus of the seismic work has been to delineate both subcropping and confined channel sandstone units in the predominantly claystone Arapahoe Formation

bedrock. EG&G (1990b) presents the reduced data and interpretations based on 14 seismic reflection lines in the Operable Unit 2 area.

1.5.3 Phase II RFI/RI Work Plan (Alluvial)

The Phase II RFI/RI Alluvial Work Plan (EG&G 1990c) presents detailed summaries of data obtained during the Phase I RI. However, both the data and the discussion of site hydrogeology and nature and extent of contamination concentrate on the geologic materials and groundwater contained in the upper hydrostratigraphic unit (HSU). The FSP contained in the Alluvial Work Plan addresses the investigation of the upper HSU (subsurface sediments above the conceptual boundary shown in Figure 1-1).

This section describes the current understanding of the site physical characteristics, the nature and extent of contamination, and potential pathways to human receptors or the environment in Operable Unit 2. Existing data were obtained from previous site investigations as summarized in Subsection 1.5. The description of site characterization presented in this work plan includes excerpts from the Alluvial Work Plan (EG&G 1990c), but it concentrates on the assimilation of data pertinent to characterizing the bedrock. Much of the bedrock data were included but not evaluated in the Alluvial Work Plan. The description of site physical characteristics and nature and extent of contamination presented in Subsections 2.1 and 2.2, respectively, were combined to develop a site conceptual model, Subsection 2.3.

2.1 SITE PHYSICAL CHARACTERISTICS

The physical characteristics of the region and plant site are presented in Subsection 1.3. Site locations and descriptions, including historical accounts of site activities, are presented in Subsection 1.4. This section of the work plan summarizes existing subsurface data and presents the current working model of the site geohydrology, emphasizing bedrock geology and the hydrostratigraphic unit(s) (HSU) underlying the upper HSU.

2.1.1 Geology

2.1.1.1 Surficial Geology

Surficial materials at the 903 Pad, Mound, and East Trenches areas consist of the Rocky Flats Alluvium, colluvium, and valley fill alluvium unconformably overlying bedrock (Figure 2-1). The area is situated on a pediment of Rocky Flats Alluvium that extends eastward from the Plant. The Rocky Flats Alluvium consists of a poorly to moderately sorted, poorly stratified deposit of clays, silts, sands, gravels, and cobbles. A portion of the 903 Pad Area extends south off the pediment toward the South Interceptor Ditch. Colluvium is present on the hillside south of the 903 Pad and East Trenches areas and on the hillside north of the Mound and East Trenches areas. Valley fill alluvium is present in the drainage of Woman Creek south of the 903 Pad and East Trenches areas and in the South Walnut Creek drainage north of the Mound Area.

Buried paleodrainages and ridges eroded into the Arapahoe Formation bedrock surface are present at the base of the Rocky Flats Alluvium (Figure 2-2). A relatively small paleogully is present, starting near the southeast corner of the Mound Area and extending southeast, where it is truncated by the hillside. A larger paleogully starts south of the east end of the East Trenches and trends northeast, traversing the central

portion of the East Trenches. A paleoridge is present on the north side of this paleogully, starting in the Mound Area and trending east-northeast across the northwest portion of the East Trenches Area. A topographic high in the bedrock surface occurs on the south side of the larger paleogully, just south of the central portion of the East Trenches.

2.1.1.2 Bedrock Geology

Significant work has been conducted recently to refine the characterization of the bedrock at Rocky Flats. A draft Geologic Characterization Report addressing Rocky Flats (EG&G 1990a) was prepared based on a comprehensive literature search, reprocessing and describing previously obtained core samples, reprocessing previously obtained seismic data, and collecting and analyzing selected samples for grain size analyses. The geologic characterization is an on-going program that will incorporate all geologic information Plant-wide for continued refinement of the working geologic model. In addition to these efforts, high-resolution seismic reflection profiling was conducted in the Operable Unit 2 area (EG&G 1990b). These two studies were conducted concurrently and the description of bedrock geology presented in this work plan utilizes the results of both. The Rocky Flats site-wide geologic characterization study is ongoing.

The Cretaceous-age Arapahoe Formation underlies surficial materials at the 903 Pad, Mound, and East Trenches areas. The high-resolution seismic reflection program indicated that the Arapahoe Formation dips at less than 2 degrees to the east. The Arapahoe Formation, which is approximately 250 feet thick in the vicinity of the Plant (EG&G 1990a), consists of fluvial claystones with interbedded sandstones, siltstones, and occasional lignite deposits. Contacts between these lithologies are both gradational and sharp.

The Arapahoe Formation was deposited by meandering streams that flowed east-southeast from the Front Range Uplift (Weimer 1973). Fining-upward graded sandstone sequences within the formation are representative of both laterally accreted point bar deposits and floodplain splay deposits. Laterally accreted point bar deposits occur by the slow migration of fluvial channels, and splay deposits are formed by breaching of channel banks during floods (Blatt et al. 1980). Overbank flood deposits consist of very fine sand and mud deposited near the stream channel or on the stream flood plain. Channel fill deposits are formed in abandoned channels by a reduction in stream discharge or by cutoff of a meander (formation of oxbow lakes) (Blatt et al. 1980).

Based on previous investigations the on-going geologic characterization by EG&G, bedrock in the 903 Pad, Mound, and East Trenches areas is predominantly claystone (EG&G 1990c). However, six channel sandstone intervals have been preliminarily identified beneath the Rocky Flats Plant. These are general stratigraphic intervals, each of which contains sandstone only at some locations. They have been sequentially numbered according to increasing depth. Thus, Arapahoe Sandstone No. 1 is the uppermost sandstone, which subcrops in many areas. Arapahoe Sandstone No. 6 is present at or near the base of the Arapahoe Formation.

Generally, the Arapahoe Sandstones that occur within 30 to 40 feet of the base of the alluvium are oxidized and are pale orange, yellowish-gray, and dark yellowish-orange. The sandstones that are not in the weathered zone are light gray and olive-gray. Most of the sandstones are very fine-to-medium grained, poorly-to-moderately sorted, subangular to subrounded, silty, clayey, and quartzitic, with trough and planar cross-stratification. The claystones and silty claystones are light-to-medium olive-gray, occasionally olive-black with some dark yellowish-orange claystones in the weathered intervals near the base of the alluvium. The yellowish-orange and yellowish-brown color is the result of the iron oxide staining.

The draft Geologic Characterization Report (EG&G 1990a) included mapping the estimated areal extent of Arapahoe Sandstone Nos. 1, 3, and 4. The lateral extent of channel deposits in each of these lithologic intervals was estimated based on previous borehole information. Figure 2-3 shows the estimated lateral extent and thickness isopachs of the Arapahoe Sandstone No. 1, and Figures 2-4 and 2-5 show the estimated lateral extents of the Arapahoe Sandstone Nos. 3 and 4. Sandstone was also found in the Number 2 and 5 intervals in several boreholes in the Operable Unit 2 area. However, there was not sufficient information to estimate the lateral extent of sandstones within these intervals. Figures 2-6A and 2-6B, 2-7A and 2-7B, and 2-8A and 2-8B show cross sections depicting the Arapahoe Sandstone intervals along three alignments through the Operable Unit 2 area. The alignments A-A', B-B', and G-G' are shown in Figures 2-3, 2-4, and 2-5. These sections are from the draft Geologic Characterization Report (EG&G 1990a).

Significant areas of the Arapahoe Sandstone No. 1 are known to subcrop beneath the Rocky Flats Alluvium in the 903 Pad, Mound, and East Trenches areas. It is believed that nearly the entire area shown as the Arapahoe Sandstone No. 1 channel subcrops beneath the Rocky Flats Alluvium. Figure 2-8C shows estimated areas of subcropping of the lower sandstone intervals. As a result of the significant areal extent of subcropping Arapahoe Sandstone No. 1, and since significant contamination has been found in this uppermost sandstone interval, all of the Arapahoe Sandstone No. 1 is presumed to be within the upper HSU. Therefore, the conceptual boundary between the alluvial and bedrock components of the RFI/RI passes beneath the Arapahoe Sandstone No. 1. Figure 1-1 shows the conceptual boundary between the alluvial and bedrock components of the RFI/RI. Although there are areas where the lower sandstone units may subcrop beneath colluvium on the valley slopes, the areal extent of these subcrops is estimated to be relatively small and the sandstone units are not considered to be in the upper HSU. Therefore, they will be treated as part of the bedrock component of the RFI/RI.

High-resolution seismic reflection profiling (EG&G 1990b; Rockwell International 1989g) was conducted to help refine the working model of the bedrock geology, particularly in the Operable Unit 2 area. There are some differences between the draft Geologic Characterization Report and the high-resolution seismic reflection profiling report in the estimated thickness and areal extent of the Arapahoe Sandstone No. 1. Since the Arapahoe Sandstone No. 1 is considered to be within the upper HSU, further characterization of it and resolution of differences between the Geologic Characterization report and high-resolution seismic profiling results will be part of the alluvial RFI/RI activities.

In general, the high resolution seismic reflection profiling was not conducted in the areas where the Arapahoe Sandstone Nos. 3 and 4 were indicated in the draft Geologic Characterization Report. Therefore, it was not determined by the seismic work conducted to date whether there may be relatively large and continuous channel deposits within these lithologic intervals as depicted in Figures 2-4 and 2-5, or whether the occurrence of fluvial channel sequences in these intervals is more localized and discontinuous. The high-resolution seismic reflection profiling report indicated the presence of two relatively small areas of relatively thick channels. The areal extents of these sandstones are shown in Figures 2-4 and 2-5, and the depths indicated by seismic results are shown in section in Figure 2-8A. They are indicated to be 50 to 60 feet thick, compared to the 10- to 20-foot thickness generally indicated for the intervals described in the draft Geologic Characterization Report. However, the interpretation of the seismic data is based to a large extent on estimates of seismic velocities. The investigation described in this work plan will include boreholes at these locations to help correlate seismic velocities with lithology. The ongoing geologic characterization by EG&G may include further work to assist in refining these interpretations. There appears to be a potential for the sandstones inferred from the seismic work to correspond to the Arapahoe Sandstone Nos. 3 through 5 intervals.

Table 2-1 presents a tabular summary of lithology, well screen intervals, and the depth of the contact between the alluvial and bedrock components of the RFI/RI based on wells and boreholes drilled into the bedrock. This information, along with the bedrock surface elevations in Figure 2-2 and Arapahoe Sandstone No. 1 isopachs shown in Figure 2-3, was used to develop a contour map of the base of the upper HSU (Figure 2-9). Note that, based on Figure 1-1, the depth to the contact between work plan components is 5 feet lower than the upper HSU bottom surface shown in Figure 2-9.

2.1.2 Groundwater Hydrology

Unconfined groundwater flow occurs in the surficial materials and in subcropping sandstones. In addition, subcropping claystones may be saturated in some locations, particularly where weathered and fractured. Confined groundwater flow occurs in the lower sandstone units, and possibly in saturated zones of claystone with sufficient hydraulic conductivity. The majority of wells that have been installed in weathered claystone throughout the Plant are unsaturated.

2.1.2.1 Groundwater Flow System in Upper HSU

Recharge/Discharge Conditions

Groundwater is present under unconfined conditions in the Rocky Flats Alluvium, colluvium, valley fill alluvium, and subcropping sandstones. Recharge to the upper HSU occurs from infiltration of incident precipitation and as seepage from ditches, creeks, and ponds.

TABLE 2-1

SUMMARY OF BOREHOLES AND WELLS IN OPERABLE UNIT 2 USED FOR BEDROCK WORK PLAN

Well/Borehole Designation	Ground Elevation	Well or Borehole	Depth to Bedrock	Thickness of SS #1	Depth to Contact between Alluvial and Bedrock RT's	Screened Depth Interval/ Lithology/HST ^(a)	LITHOLOGY ^(b)					
							SS #1	SS #2	SS #3	SS #4	SS #5	Claystone/Siltstone
2686	5954.06	W	10.5		15.5	4.0-13.5/AL/U						10.5-17.0
3486	5910.44	W	15.9		20.9	44.2-56.2/SS#3/L			48.0-54.0			15.9-44.2, 54.0-100.0
4086	5941.23	W	45.0		50.0	88.0-111.5/CS/L			118.0-122.0			45.0-118.0, 122.0-124.8
4186	5940.03	W	44.6		49.6	3.9-44.7/AL/U						
4286	5954.34	W	28.3		33.3	6.1-29.7/AL/U						28.3-35.0
5986	5914.32	W	7.5		12.5	19.0-28.0/SS#3/L			20.0-23.5			7.5-20.0, 23.5-32.5
6286	5897.54	W	22.0		27.0	25.2-35.2/SS#3/U			25.3-33.0	40.3-47.3	50-59.3	22.0-25.3, 33.0-40.3, 47.3-50.0
6386	5896.55	W	14.8		19.8	3.8-15.2/AL/U						14.8-17.3
287	5930.56	W	7.30		12.3	3.2-9.1/AL/U			27.9-30.3			7.3-16.0
0387	5930.58	W	20.8		25.8	102.8-107.8/CS/L			45.7-51.0			20.8-27.9, 30.3-117.0
0587BR	5927.76	W	11.0		16.0	42.0-51.2/SS#3/L			12.2-26.8	30.0-32.6		11.0-45.7, 51.0-61.0
687A	5898.22	B	5.2		10.2	ABANDONED			38.6-47.6			5.2-12.2, 26.8-30.0
787BRA	5928.21	B	6.0		1.0	ABANDONED			18.9-31.2			6.0-38.6
887BR	5919.70	W	8.7		13.7	84.0-89.0/CS/L						8.7-18.9, 31.2-106.0
987	5980.22	W	12.7	19.2	36.9	14.5-32.1/SS#1/U	12.7-31.9					31.9-37.5
1087	5981.96	W	11.3	6.0	22.3	3.5-12.0/AL/U	11.3-17.3					
1287BR	5934.74	W	3.5		8.5	4.9-10.5/CS/U						3.5-15.9
1487BR	5855.00	W	5.2		10.2	19.0-24.0/SS#3/L				9-12.5	19-25.5	5.2-9.0, 12.5-19.0
1587	5970.89	W	21.9		26.9	5.8-22.1/AL/U						21.9-27.0
1687BR	5969.06	W	22.2		27.2	99.5-125.0/SS#3/L			100.5-117.0	140.5-144.5		22.2-100.5, 117.0-140.5, 144.5-174
1787	5967.56	W	25.0		30.0	3.5-25.5/AL/U						25.0-30.3
1887BR	5967.38	W	25.2		30.2	127.0-133.4/SS#4/L			109.2-117.2	127.0-133.2		25.2-109.2, 133.2-147.0
2087BR	5968.10	W	11.8		16.8	107.3-116.1/SS#3/L			107.3-116.3			11.8-107.3, 116.3-126.2
2187	5927.58	W	8.0		13.0	3.2-10.4/AL/U						8.0-17.0
2287BR	5930.70	W	12.8		17.8	81.0-89.1/SS#4/L				83.8-87.8	96.0-101.0	12.8-83.8, 87.8-96.0, 101.0-111.0
2387BR	5972.34	W	15.2	17.5	37.7	17.2-37.6/SS#1/U	15.2-32.7					32.7-45.3
2487	5957.79	W	15.1		20.1	3.5-13.6/AL/U						15.1-18.3
2587BR	5958.91	W	16.5	27.2	48.7	17.5-43.5/SS#1/U	17.5-44.7					16.5-17.5, 44.7-47.0
2787	5947.52	W	44.2		49.2	3.5-43.0/AL/U						44.2-47.7
2887BR	5947.17	W	43.5		48.5	187.4-197.4/CS/L			109.0-118.0			43.5-109.0, 118.0-207.0

Phase II RFI/RI Work Plan (Bedrock)-903 Pad, Mound, and East Trenches Areas, Draft Final
Rocky Flats Plant, Golden, Colorado, February 4, 1991
22578E/RI/2-1 02-04-91/RPT/2

TABLE 2-1
SUMMARY OF BOREHOLES AND WELLS IN OPERABLE UNIT 2
USED FOR BEDROCK WORK PLAN
(Continued)

Well/Borehole Designation	Ground Elevation	Well or Borehole	Depth to Bedrock	Thickness of SS #1	Depth to Contact between Alluvial and Bedrock RT's	Screened Depth Interval/ Lithology/HSTU ^(a)	LITHOLOGY ^(a)					
							SS #1	SS #2	SS #3	SS #4	SS #5	Claystone/Siltstone
3087BR	5811.87	W	16.0		21.0	85.8-94.4/CS/L						16.0-110.0
3187BR	5945.02	W	45.0		50.0	110.7-129.4/SS#3/L			112.5-129.0			45.0-112.5, 129.0-140.0
3287	5946.12	W	46.2		51.2	36.0-46.6/AL/U						46.2-51.3
3387	5945.27	W	19.0		24.0	15.0-20.0/AL/U						19.0-24.5
3487BR	5945.21	W	20.0		25.0	97.3-104.2/CS/L						20.0-124.0
3587	5949.36	W	9.1		14.1	3.5-9.3/AL/U						9.1-14.4
3687BR	5949.04	W	7.4	25.5	37.9	19.8-63.3/SS#1/CS/U	20.0-45.5					7.4-20.0, 45.5-74.5
4487	5956.10	B	3.2		8.2	1.5-3.5/AL/U						3.2-7.0
4587BR	5949.42	W	4.0		9.0	89.5-101.0/SS#5/L					97.0-101.0	4.0-97.0, 101.0-112.0
4987	5912.68	W	9.0		14.0	1.8-4.8/AL/U						9.0-10.0
5087	5933.21	W	12.5		17.5	3.5-13.5/AL/U		14.5-27.0		121.2-128.2		12.5-14.5
5689BR (B217489)	5961.20	W	25.3	14.0	44.3	142.0-148.7/CS/L	27.0-41.0					25.3-27.0, 41.0-121.2, 128.2-220.0
5789BR (B217589)	5952.90	W	17.3		22.3	85.2-92.9/SS#4/L				82.5-92.9		17.3-85.2, 92.9-221.3
5889BR (B217689)	5960.50	W	25.0	29.0	59.0	98.5-105.1/SS#4/L				97.2-103.1		25.0-97.2, 103.1-220.1
6089BR (B217789)	5954.80	W	23.6		28.6	72.0-86.0/CS/L			138.6-146.6	150.6-207.0		23.6-138.6, 146.6-150.6, 207.0-220.0
BH1587	5954.20	B	4.5		9.5							4.5-13.0
BH1787	5956.00	B	5.3		10.3							5.3-12.0
BH2287	5928.50	B	22.2		27.2							22.2-27.2
BH2387	5964.20	B	8.0		13.0							8.0-12.5
BH2487	5953.60	B	4.9		9.9							4.9-12.3
BH2587	5953.20	B	14.8		19.8							14.8-22.5
BH2787	5944.70	B	9.9		14.9							9.9-17.0
BH2887	5946.70	B	5.9		10.9							5.9-9.0
BH3187	5973.80	B	7.6	2.2	14.8		8.0-10.2					7.6-8.0, 10.2-15.9
BH3287	5971.70	B	7.7	6.9	19.6		7.7-14.6					
BH3387	5967.90	B	9.2	4.3	18.5		9.2-13.5					
BH3487	5971.40	B	16.7	8.0	29.7		16.7-24.7					
BH3587	5970.50	B	14.3	6.0	25.3		14.3-20.3					
BH3687	5964.40	B	20.6		25.6							20.6-24.5

Phase II RFI/RI Work Plan (Bedrock)-903 Pad, Mound, and East Trenches Areas, Draft Final
Rocky Flats Plant, Golden, Colorado, February 4, 1991
22578E/RIIT-2-1 02-04-91/RPT/2

TABLE 2-1
SUMMARY OF BOREHOLES AND WELLS IN OPERABLE UNIT 2
USED FOR BEDROCK WORK PLAN
(Concluded)

Well/Borehole Designation	Ground Elevation	Well or Borehole	Depth to Bedrock	Thickness of SS #1	Depth to Contact between Alluvial and Bedrock RT's	Screened Depth Interval/ Lithology/HSU ^(a)	LITHOLOGY ^(b)				
							SS #1	SS #2	SS #3	SS #4	SS #5
BH3787	5968.80	B	14.0	6.3	25.3	21.7-28.0					14.6-23.4
BH3887	5965.30	B	14.6		19.6						
BH3987	5956.90	B	14.5	7.5	27.0	14.5-22.0					8.0-14.5
BH4087	5953.70	B	8.0		13.0						15.0-19.5
BH4187	5950.20	B	15.0		20.0						50.8-55.5
BH4287	5950.50	B	24.0	26.8	55.8	24.0-50.8					27.2-34.7
BH4387	5956.50	B	27.2		32.2						33.3-34.5
BH4487	5956.10	B	27.0	6	38.2	27.1-33.3					
BH4587	5952.70	B	20.0	20.0	45.0	20.0-40.0					
BH4687	5952.60	B	27.0		32.0						27.0-32.0
BH4787	5951.40	B	26.2		31.2						27.7-30.0
BH4887	5949.40	B	13.2		18.2						13.2-17.3
BH4987	5953.00	B	22.0		27.0						22.0-25.8
BH5087	5949.20	B	12.0		17.0						
BH5587	5944.90	B	37.0		42.0						37.0-40.0

^(a) HSU = Hydrostratigraphic Unit
 U = Portion of well screen or entire well screen in upper HSU
 L = Entire well screen in lower HSU(s) based on boundary between "alluvial" and "bedrock" components of RFI/RI shown in Figure (1-1)

^(b) SS#1 = Anapahoe Formation Sandstone Number 1
 SS#2 = Anapahoe Formation Sandstone Number 2
 SS#3 = Anapahoe Formation Sandstone Number 3
 SS#4 = Anapahoe Formation Sandstone Number 4
 SS#5 = Anapahoe Formation Sandstone Number 5
 CS = Anapahoe Formation Claystone/Siltstone

The shallow groundwater flow system is dynamic, with large water level changes occurring in response to precipitation events and stream and ditch flow. Alluvial water levels are highest during the spring and early summer months of May and June. Water levels generally decline during the second half of the year, at which time some wells go dry. The shallow groundwater flow system supports ephemeral flow in the creeks.

Alluvial groundwater discharges from seeps to colluvium in surface water drainages, and to subcropping Arapahoe Sandstone in the 903 Pad, Mound, and East Trenches areas. Seeps occur along the edge of the pediment (at the alluvium/bedrock contact) and on the hillside slopes. Visible seeps on the hillsides may be due to thinning of colluvial materials. There are several seeps downslope to the southeast of the 903 Pad. Surface water stations established at these seeps in the 903 Pad Lip Area are designated SW-50, SW-51, SW-52, SW-55, SW-57, SW-58, and SW-77. Figure 2-10 shows the locations of these seeps in relation to areas of potential sandstone subcrops on the hillside. Station SW-50 is closest to the 903 Pad, and SW-57 and SW-52 are south of SW-50. SW-51 and SW-58 are located in a ditch along the road east of SW-50. Overland flow of seepage from SW-50, SW-52, and SW-57 enter the ditch. Water in the ditch passes under the road south of these locations through a culvert. The discharge of the culvert is SW-55. SW-77 is another seep located on the east side of the road, just north of SW-55. It is noted therefore, that SW-51, SW-58, and SW-55 are physically connected and likely receive flow from SW-50, SW-52, and SW-57. Farther downgradient stations include seeps at SW-53, SW-62, SW-63, and SW-64; SW-27, SW-30, SW-54, and SW-70 on the South Interceptor Ditch; and SW-26, SW-28, and SW-29 on Woman Creek. Ground water in valley fill materials discharges to Woman Creek or South Walnut Creek.

Groundwater Flow Directions

Groundwater flow in the unconfined system is generally from west to east. Figure 2-11 depicts the potentiometric surface for the upper HSU, measured in April 1988, and represents the most extensive area of saturation at Operable Unit 2 measured since the Phase I RI (EG&G 1990e). For the purpose of this work plan, this is intended to represent a typical seasonal high water table. This figure is based on water level data for wells completed in both surficial materials and subcropping sandstones that exhibit unconfined conditions. Groundwater flow within the Rocky Flats Alluvium generally follows the topography and on a large scale is predominantly eastward in the area. Groundwater flow directions in the subcropping sandstones are probably influenced by the geometry of the sandstone channels (see Figure 2-9). Groundwater flowing toward the pediment edges emerges from seeps at the contact between the alluvium and claystone bedrock (contact seeps), is consumed by evapotranspiration, or flows through colluvial materials following topography toward the valley fill alluvium. Once groundwater reaches the valley fill alluvium, it either flows down-valley in the alluvium, is consumed by evapotranspiration, or discharges to the creek. During the driest periods of the year, evapotranspiration consumes enough water that there is no flow in either the colluvium or the valley fill alluvium. Therefore, wells completed in these areas are typically dry during some portion of the year.

Groundwater Flow Rates

Hydraulic conductivity values were estimated for surficial materials based on drawdown-recovery tests performed on 1986 wells during the initial site characterization (Rockwell International 1986e) and from slug tests performed on selected 1986 and 1987 wells during the 1987 Phase I RI.

For the Rocky Flats Alluvium, the hydraulic conductivity values reported based on all hydraulic tests in wells range from 4×10^{-5} centimeters per second (cm/s) at Well 3986 to 5×10^{-2} cm/s at Well 4286. The geometric mean hydraulic conductivity for all tests was 4×10^{-4} cm/s. Based on an average horizontal gradient of 0.02 feet/foot (ft/ft) at the 903 Pad, Mound, and East Trenches areas, an assumed effective porosity of 0.1, and a mean hydraulic conductivity of 4×10^{-4} cm/s, the average groundwater velocity in the Rocky Flats Alluvium is 85 feet per year (ft/yr) (Rockwell International 1987a). Based on the ranges of hydraulic conductivity values, the average linear velocity of groundwater ranges from about 8 ft/yr to 10,300 ft/yr (EG&G 1990c).

The geometric mean hydraulic conductivity based on drawdown-recovery tests for the Woman Creek valley fill alluvium is 7×10^{-4} cm/s, and the range is from 5×10^{-5} cm/s at Well 6886 to 3×10^{-3} cm/s at Well 6586. No slug tests were performed on wells completed in Woman Creek valley fill. Assuming a horizontal gradient of 0.02 ft/ft, an assumed effective porosity 0.1, and a mean hydraulic conductivity of 7×10^{-4} cm/s, the average linear velocity of groundwater in Woman Creek valley fill is 145 ft/yr (Rockwell International 1987a). Estimates of average linear velocity of the groundwater range from about 10 to 620 ft/yr, based on the range of hydraulic conductivity values (EG&G 1990c).

South Walnut Creek valley fill is less conductive than that along Woman Creek, based on lithologic descriptions and hydraulic conductivity tests of Well 3586. A drawdown-recovery test and a slug test have been performed in Well 3586. The hydraulic conductivity of South Walnut Creek Alluvium calculated from the drawdown-recovery test was 9×10^{-5} cm/s. Results of the slug test indicated a hydraulic conductivity of 1×10^{-4} cm/s. Assuming a mean conductivity of 9.5×10^{-5} cm/s, an effective porosity of 0.1, and an average gradient of 0.02 ft/ft, the average linear velocity of groundwater in South Walnut Creek valley fill is estimated to be about 20 ft/yr (Rockwell International 1987a).

The estimated average linear velocities of groundwater calculated for various surficial materials assume the materials are fully saturated year-round. However, as discussed above, portions of the Rocky Flats Alluvium, colluvium, and valley fill alluviums are not saturated during the entire year. In some areas the shallow groundwater flow occurs only nine months of the year (generally November through July). Thus, in such areas the resultant average linear velocity of groundwater, calculated as a yearly estimate, would be reduced in the shallow alluvial materials (approximately 65 ft/yr in Rocky Flats Alluvium, 110 ft/yr in Woman Creek valley fill alluvium, and 15 ft/yr in South Walnut Creek valley fill alluvium [EG&G 1990c]).

2.1.2.2 Confined Groundwater Flow System(s)

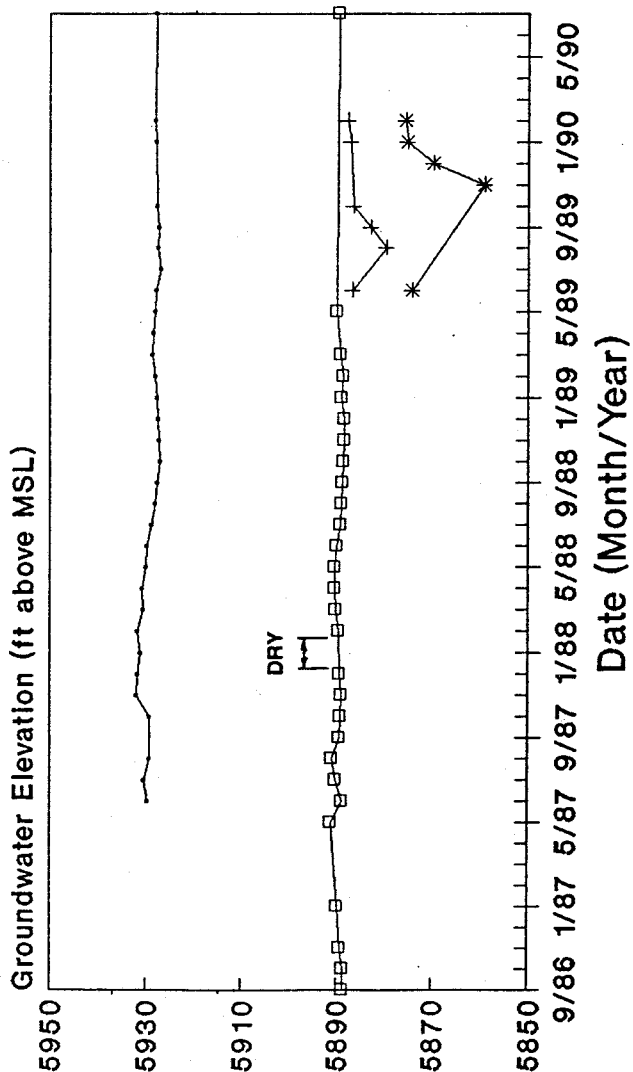
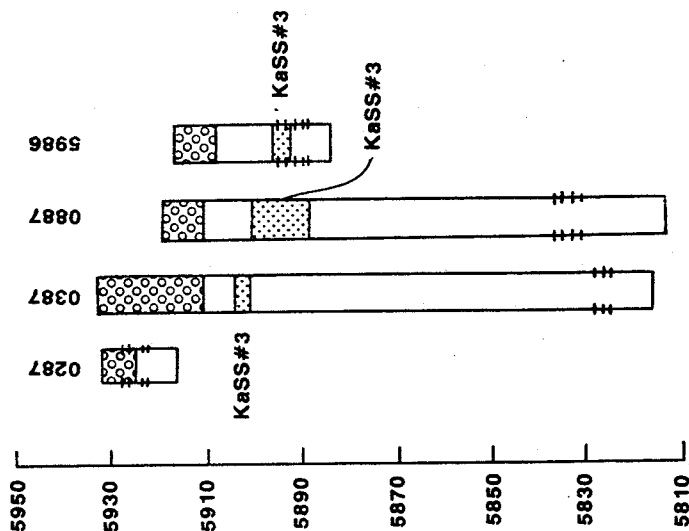
Flow within the lower sandstones is believed to generally be from west to east, consistent with the gradual easterly dip of the bedrock; however, the geometry of the sandstone units and the groundwater flow paths in the bedrock are not well understood at this time. Also, there is not sufficient information to estimate groundwater flow rates in the lower sandstones. To estimate flow rates would require knowledge of hydraulic gradients within the individual sandstone units and further characterization of hydraulic conductivity and effective porosity values in the bedrock units.

The results of packer tests conducted in the bedrock during the Phase I RI generally indicate low values of hydraulic conductivity, on the order of 1×10^{-8} to 1×10^{-6} cm/sec, in both the unweathered sandstones and claystone. Although not supported by the available packer test data, geologic descriptions and particle size data on the sandstone and claystone indicate that the highest confined groundwater flow rates occur in the sandstones contained within the claystones. Slug tests conducted in wells screened in the unconfined Arapahoe Sandstone No. 1 indicated higher hydraulic conductivities in the range of 5×10^{-5} to 1×10^{-3} cm/sec (Well 0987) (data presented in appendixes to Rockwell International 1987a).

Figures 2-12 through 2-20 present well hydrographs for selected wells located near each other. These hydrographs demonstrate that relatively high downward potential gradients generally occur in the Arapahoe Formation across the site. The lowest vertical gradient shown in Figures 2-12 through 2-20 was calculated to be approximately 0.33, between Well 5986, which is screened in the Arapahoe Sandstone No. 3, and Well 0887, which is screened in claystone at depths between 84 and 89 feet. These two wells are located in the 881 Hillside area to the west of the southwest corner of Operable Unit 2.

The relatively high vertical hydraulic gradient in the bedrock indicates that flow which occurs in the unweathered claystone will tend to be predominantly in a downward direction. However, based on the geologic description of the unweathered claystones, it is currently believed that the downward flow of groundwater through the claystones will be impeded by the low hydraulic conductivity of these deposits. The groundwater flow rates through the claystone are expected to depend primarily on the degree of weathering or fracturing (i.e., secondary hydraulic conductivity) rather than on the porosity and permeability in the pore spaces between individual soil particles (i.e., primary effective porosity and hydraulic conductivity).

LITHOLOGY AND WELL INFORMATION



— Well 287 + Well 387 * Well 887 — Well 5986

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EXPLANATION

- ALLUVIUM
- SANDSTONE
- CLAYSTONE/
SILTSTONE
- WELL SCREEN
INTERVAL

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

WELL HYDROGRAPHS (LOWER 881 HILLSIDE)

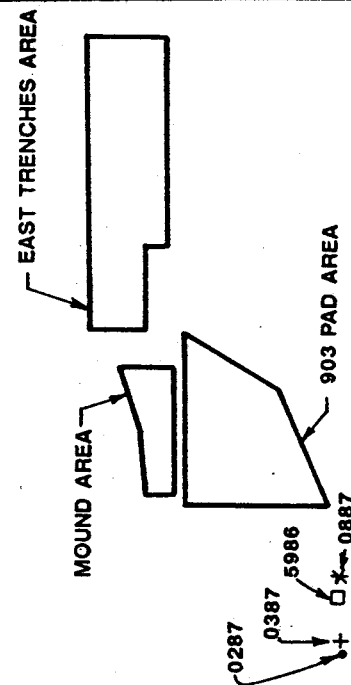
Figure 2-12

1/24/91

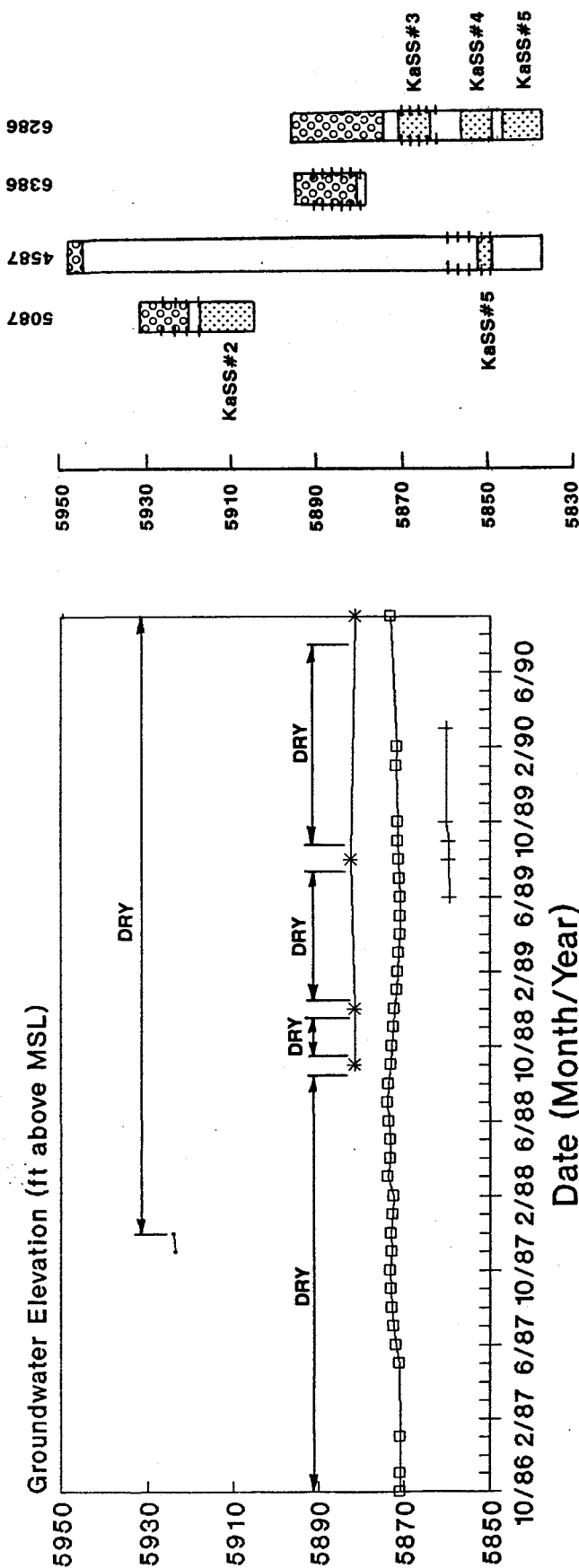
APPARENT VERTICAL GROUNDWATER GRADIENTS ($\Delta H/L$)

INTERVAL	* GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
0287-0387	0.48	28
0887-5986	0.33	28

* GRADIENTS ARE POSITIVE DOWNWARD



LITHOLOGY AND WELL INFORMATION



Date (Month/Year)

Well 5087 — Well 4587 * Well 6386 — Well 6286

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U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

**WELL HYDROGRAPHS
(SOUTH 903 PAD AREA)**

EXPLANATION

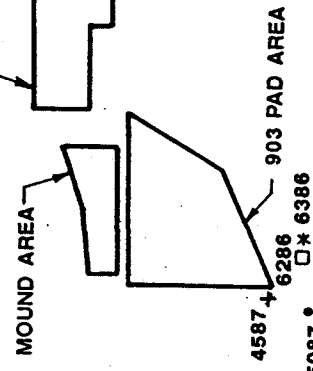
- ALLUVIUM
- SANDSTONE
- CLAYSTONE/
SILTSTONE
- WELL SCREEN
INTERVAL

APPARENT VERTICAL GROUNDWATER GRADIENTS ($\Delta H/L$)

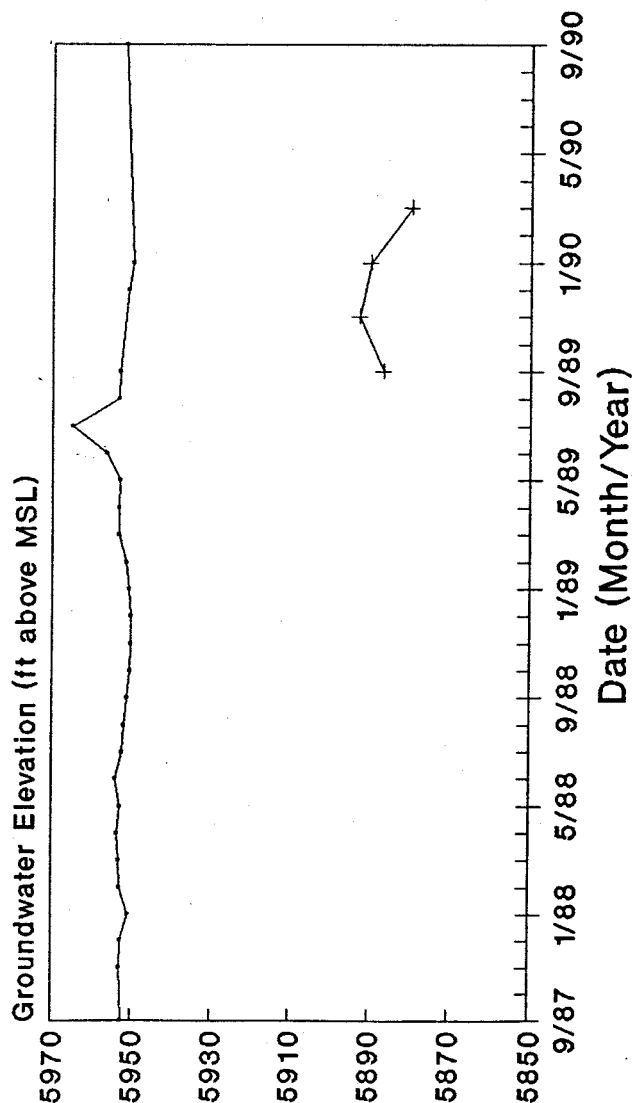
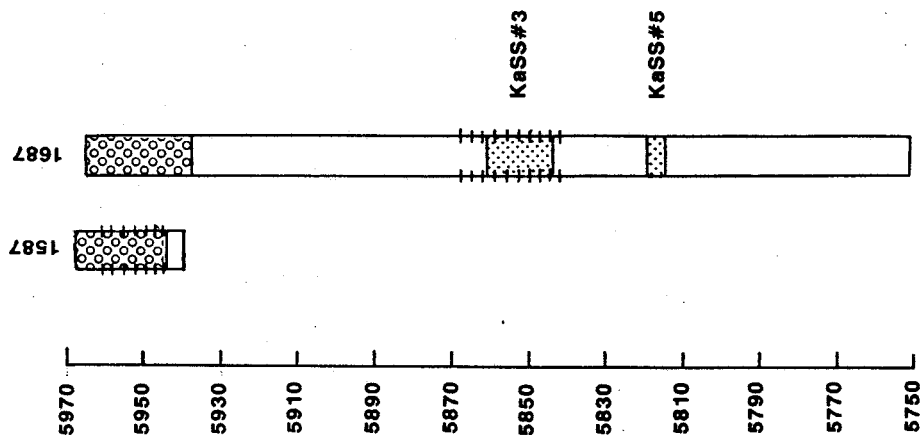
INTERVAL	*GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
6386-6286	0.94	29

* GRADIENTS ARE POSITIVE DOWNWARD

EAST TRENCHES AREA



LITHOLOGY AND WELL INFORMATION



— Well 1587 — Well 1687

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APPARENT VERTICAL GROUNDWATER GRADIENTS ($\Delta H/L$)	
INTERVAL	* GRADIENT (ft/ft)
1587-1687	0.65
HORIZONTAL DISTANCE BETWEEN WELLS (ft)	
120	

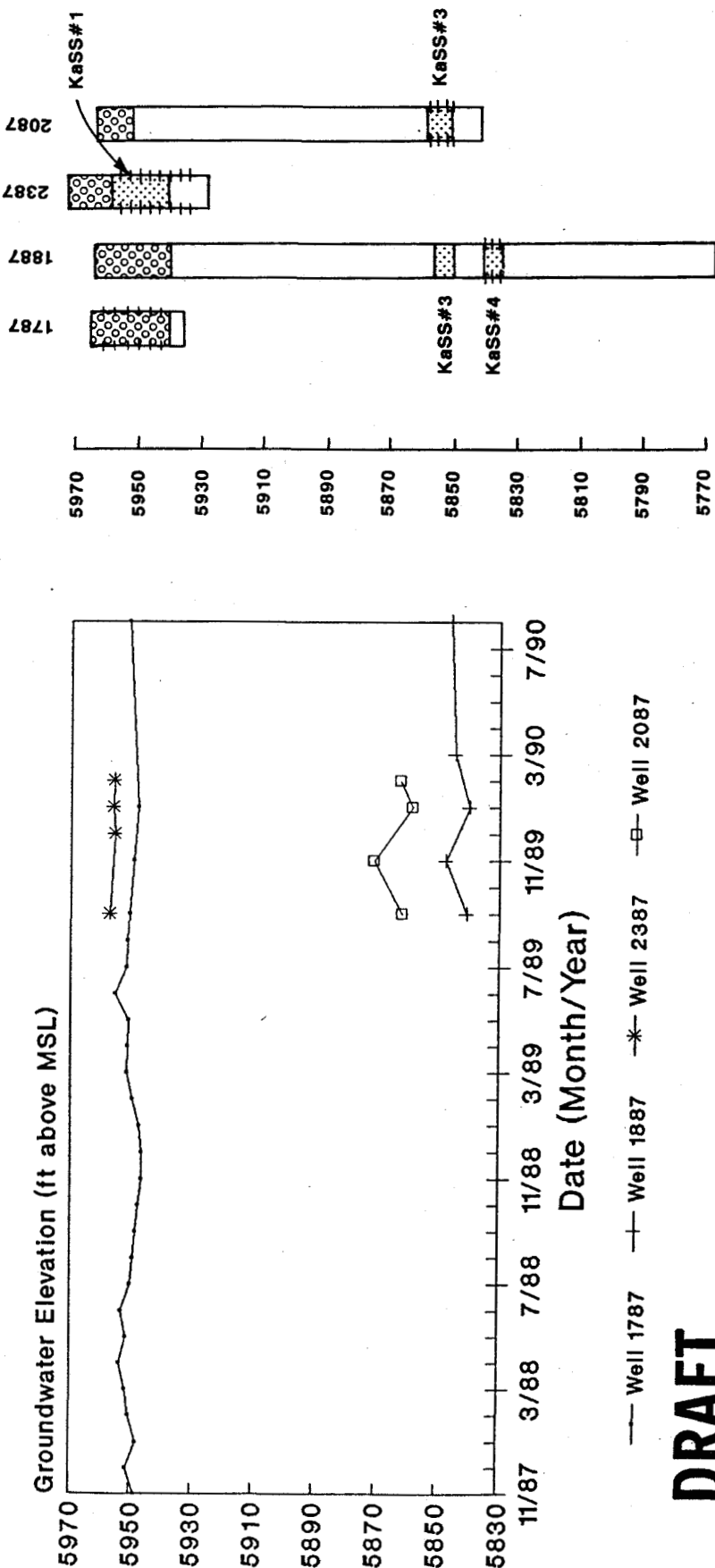
* GRADIENTS ARE POSITIVE DOWNWARD

EXPLANATION	
	ALLUVIUM
	SANDSTONE
	CLAYSTONE/SILTSTONE
	WELL SCREEN INTERVAL

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

WELL HYDROGRAPHS (903 PAD AREA)

LITHOLOGY AND WELL INFORMATION



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U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RJ WORK PLAN (BEDROCK)

WELL HYDROGRAPHS (MOUND AREA)

EXPLANATION

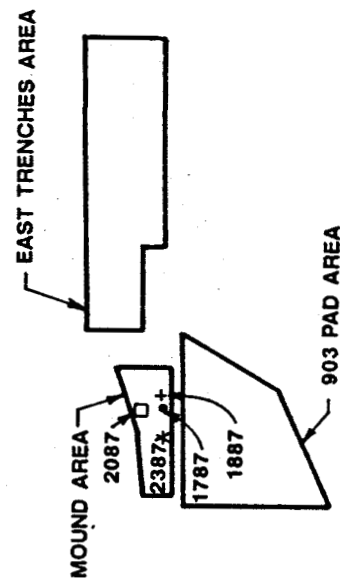
- ALLUVIUM
- SANDSTONE
- CLAYSTONE/
SILTSTONE
- WELL SCREEN
INTERVAL

APPARENT VERTICAL GROUNDWATER GRADIENTS ($\Delta H/L$)

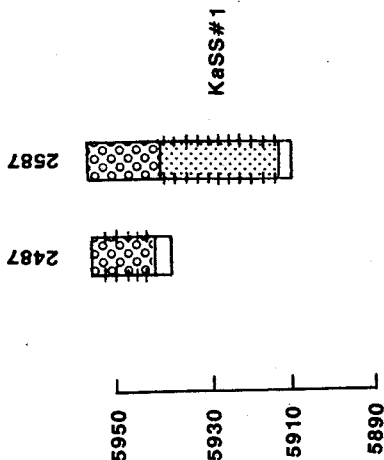
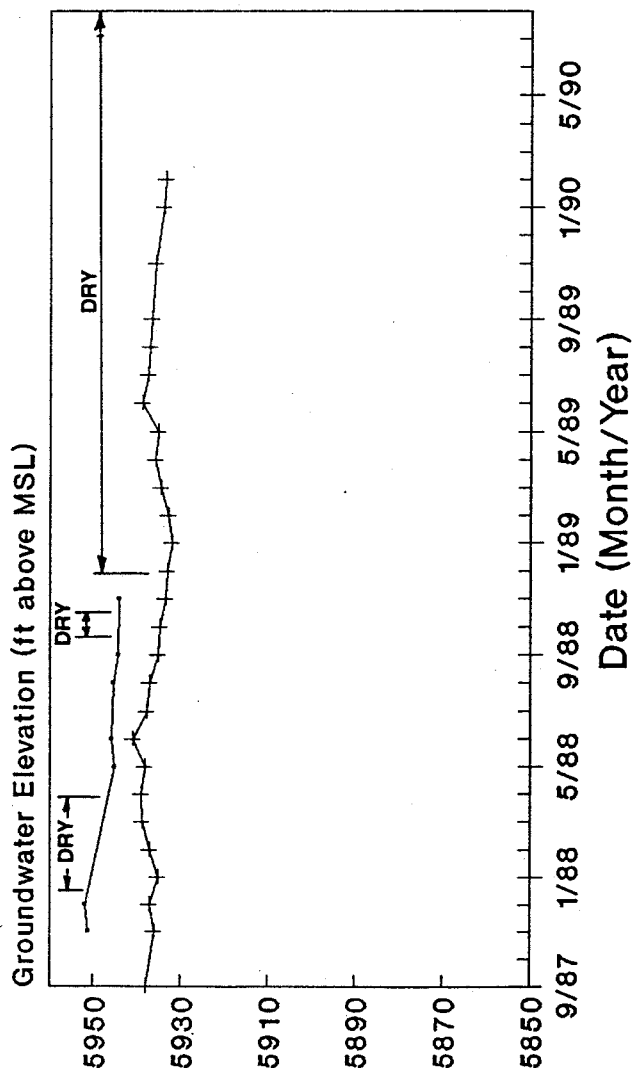
INTERVAL *GRADIENT
(ft/ft)

1787-1887	0.92
1787-2087	0.90
1887-2387	1.04
1887-2087	1.02
2387-2087	1.06

* GRADIENTS ARE POSITIVE DOWNWARD



LITHOLOGY AND WELL INFORMATION



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U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

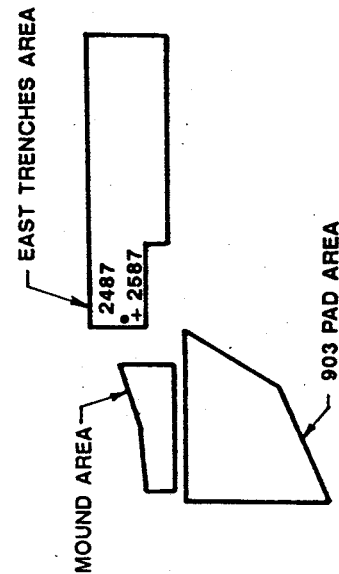
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

**WELL HYDROGRAPHS
(WEST-EAST TRENCHES AREA)**

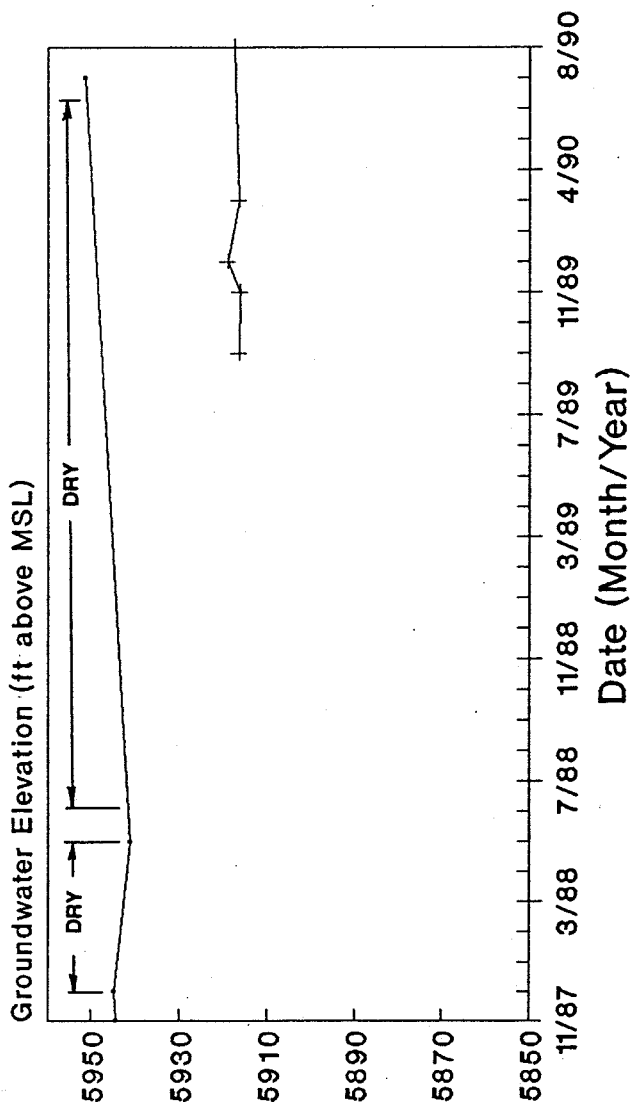
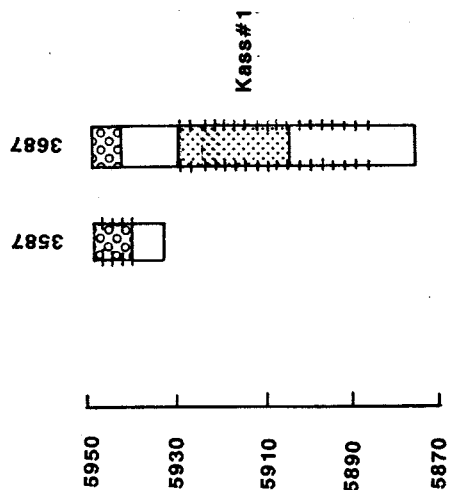
EXPLANATION	
	ALLUVIUM
	SANDSTONE
	CLAYSTONE/ SILTSTONE
	WELL SCREEN INTERVAL

APPARENT VERTICAL GROUNDWATER GRADIENTS ($\Delta H/L$)	
INTERVAL	* GRADIENT (ft/ft)
2487-2587	0.51
HORIZONTAL DISTANCE BETWEEN WELLS (ft)	
	32

* GRADIENTS ARE POSITIVE DOWNWARD



LITHOLOGY AND WELL INFORMATION



— Well 3587 — Well 3687

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U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)
**WELL HYDROGRAPHS
(WEST CENTRAL-EAST
TRENCHES AREA)**

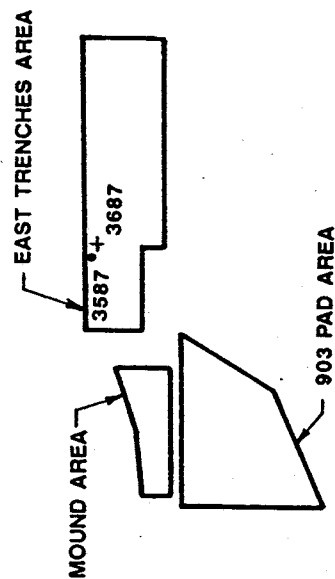
EXPLANATION

	ALLUVIUM
	SANDSTONE
	CLAYSTONE/ SILTSTONE
	WELL SCREEN INTERVAL

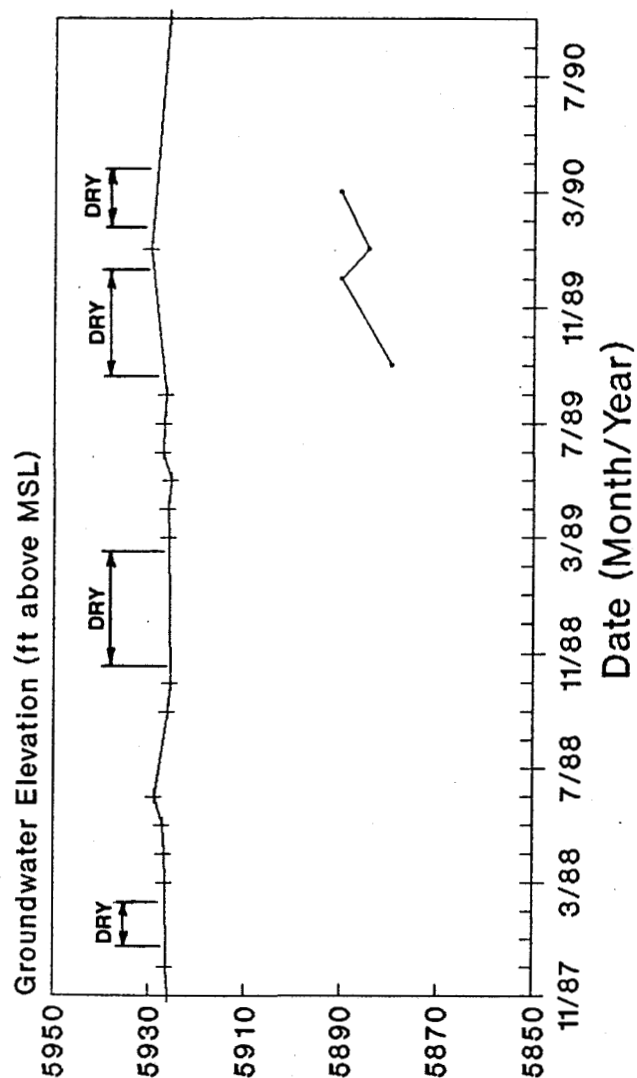
APPARENT VERTICAL GROUNDWATER GRADIENTS ($\Delta H/L$)

INTERVAL	* GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
3587-3687	0.80	27

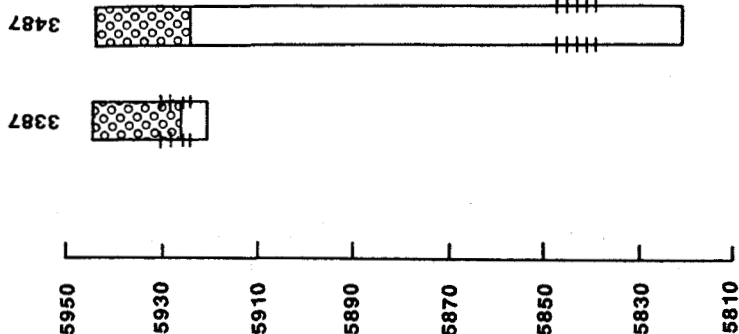
* GRADIENTS ARE POSITIVE DOWNWARD



LITHOLOGY AND WELL INFORMATION



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EXPLANATION

	ALLUVIUM
	SANDSTONE
	CLAYSTONE/ SILTSTONE
	WELL SCREEN INTERVAL

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

WELL HYDROGRAPHS (CENTRAL-EAST TRENCHES AREA)

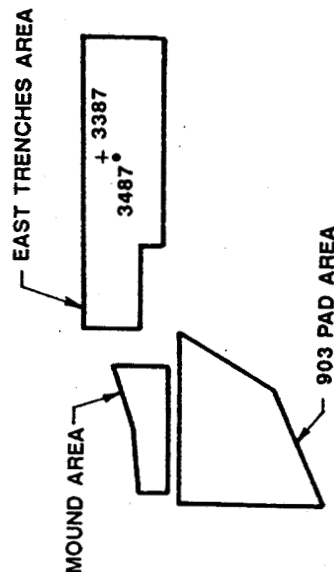
Figure 2-18

1/24/91

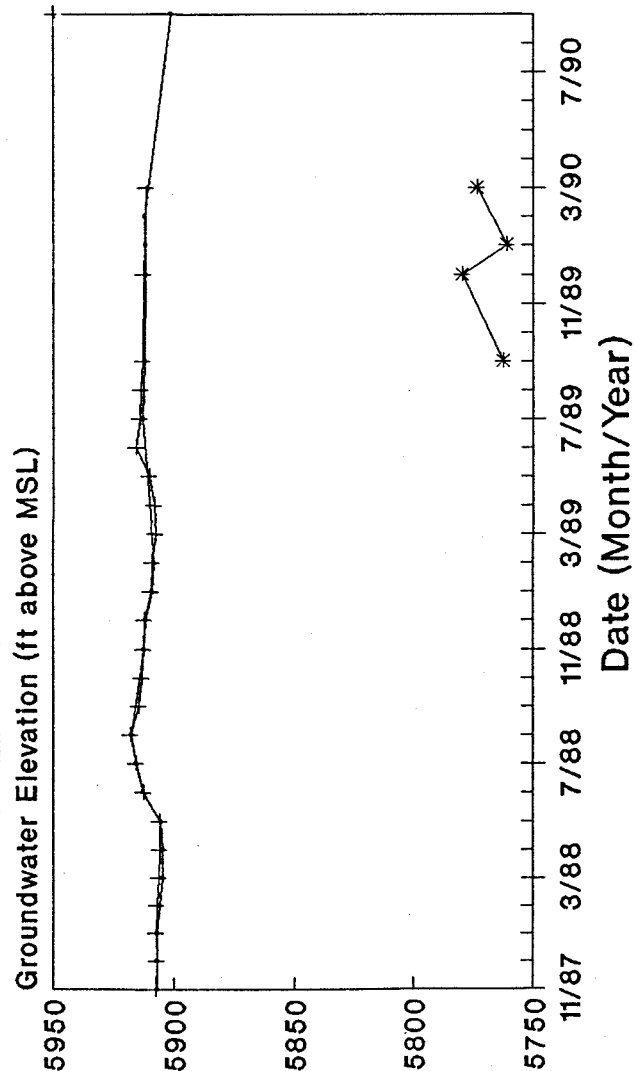
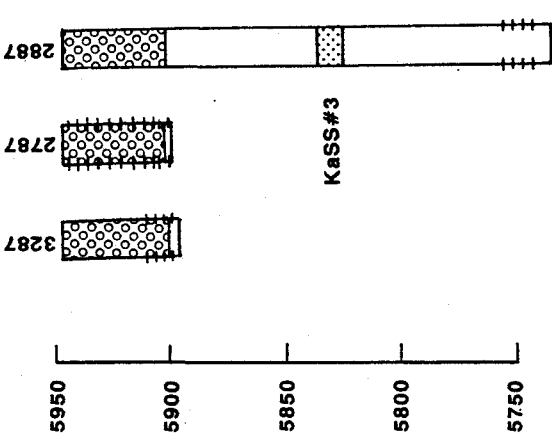
APPARENT VERTICAL GROUNDWATER GRADIENTS ($\Delta H/L$)

INTERVAL	*GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
3487-3387	0.49	22

* GRADIENTS ARE POSITIVE DOWNWARD



LITHOLOGY AND WELL INFORMATION



—+— Well 3287 —+— Well 2787 *— Well 2887

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U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

WELL HYDROGRAPHS (SOUTH CENTRAL-EAST TRENCHES AREA)

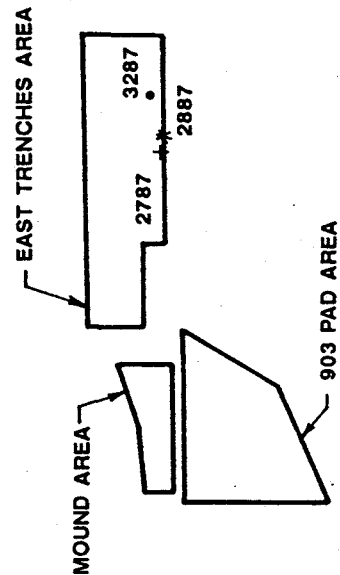
EXPLANATION

- ALLUVIUM
- SANDSTONE
- CLAYSTONE/
SILTSTONE
- WELL SCREEN
INTERVAL

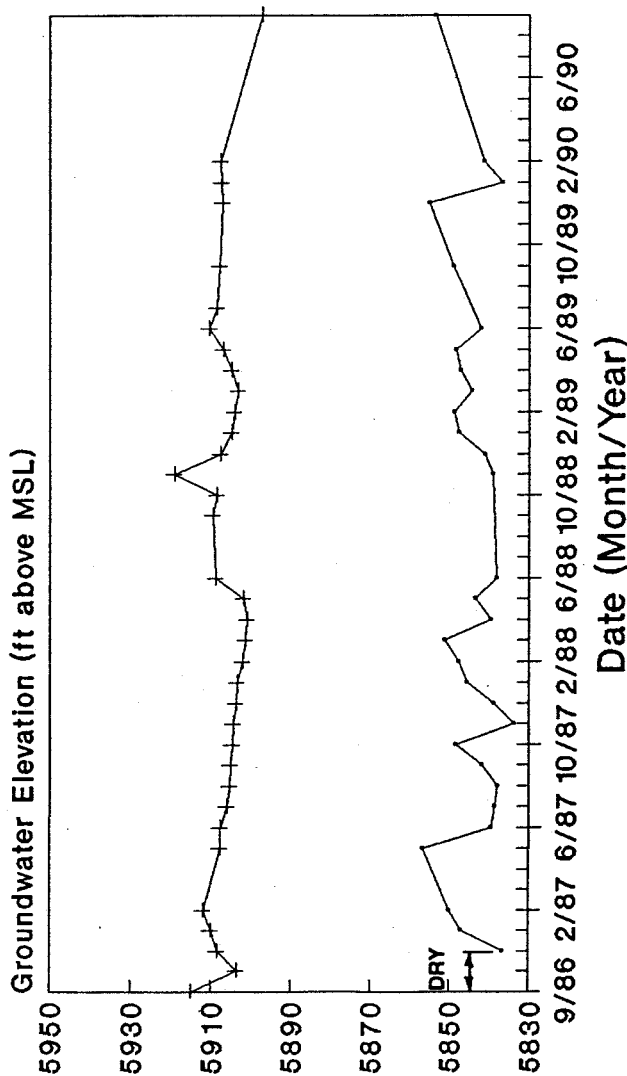
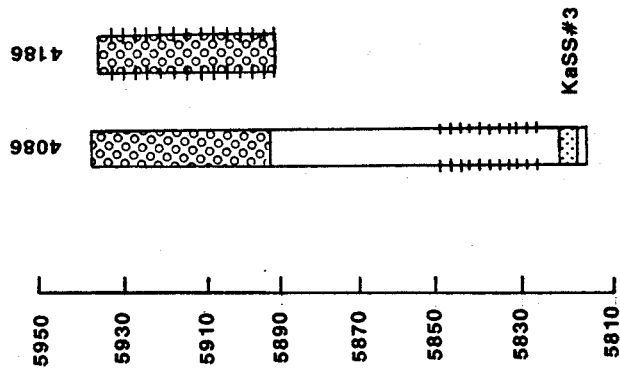
APPARENT VERTICAL GROUNDWATER GRADIENTS ($\Delta H/L$)

INTERVAL	*GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
3287-2787	NEAR 0	319
2787-2887	0.83	38

* GRADIENTS ARE POSITIVE DOWNWARD



LITHOLOGY AND WELL INFORMATION



— Well 4086 — Well 4186

DRAFT

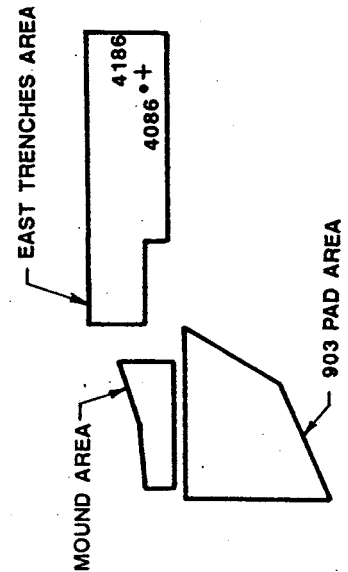
APPARENT VERTICAL GROUNDWATER GRADIENTS ($\Delta H/L$)	
INTERVAL	*GRADIENT (ft/ft)
4086-4186	0.84
	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
	39

* GRADIENTS ARE POSITIVE DOWNWARD

EXPLANATION	
	ALLUVIUM
	SANDSTONE
	CLAYSTONE/SILTSTONE
	WELL SCREEN INTERVAL

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

**WELL HYDROGRAPHS
(EAST-EAST TRENCHES AREA)**



2.1.3 Surface Water Hydrology

2.1.3.1 South Walnut Creek

The headwaters of South Walnut Creek were filled during construction of Plant facilities. The drainage from the Central Avenue area between the 903 Pad Area and the Mound Area is diverted into a large-diameter corrugated metal pipe that discharges into South Walnut Creek beneath a perimeter access road embankment outside of the Perimeter Security Zone (PSZ).

A second culvert is a large-diameter concrete culvert that diverts storm flows from the area east of Building 991 within the PSZ to South Walnut Creek. This concrete culvert also discharges beneath the perimeter access road and into the South Walnut Creek drainage.

A third culvert diverts flows from the western part of the PSZ to a point downstream of the two culverts described above. The third culvert terminates near the sewage plant discharge channel in South Walnut Creek. The combined flows, typically less than 10 gallons per minute (gpm) based on flow data from the first three quarters of 1989, then enter the South Walnut Creek retention pond system. Below the retention ponds, South Walnut Creek joins North Walnut Creek and an unnamed tributary within the buffer zone before flowing into Great Western Reservoir located approximately one mile east of this confluence.

The South Walnut Creek retention pond system consists of five ponds (B-1, B-2, B-3, B-4 and B-5) that retain surface water runoff and Plant discharges for monitoring and evaluation before downstream release of these waters. The South Walnut Creek drainage is located in Operable Unit 6, which is just north of Operable Unit 2. Ponds B-1 and B-2 are reserved for spill control, surface water runoff, or treated sanitary waste of unknown quality, and Pond B-3 is a holding pond for sanitary sewage treatment plant effluent. In the past, the normal discharge of Pond B-3 was to a spray system located in the vicinity of the East Trenches. The spray system has ceased operating since then. Ponds B-4 and B-5 receive surface water runoff from the central portion of the Plant and occasional discharges from Pond B-3. The surface water runoff received by Pond B-4 is collected by the Central Avenue Ditch and upper reaches of South Walnut Creek. This includes storm runoff diverted via the two large-diameter culverts. The discharge of Pond B-5 is currently released to retention Pond A-4, located in the North Walnut Creek drainage.

2.1.3.2 Woman Creek

Woman Creek is located south of the Plant with headwaters in largely undisturbed Rocky Flats Alluvium. Runoff from the southern part of the Plant is collected in the South Interceptor Ditch located due north of the creek and delivered to Pond C-2. Pond C-1 (upstream of C-2) receives stream flow from Woman Creek. The Woman Creek drainage is located in Operable Unit Number 5, which is just south of Operable Unit Number 2. The discharge from Pond C-1 is diverted around Pond C-2 into the Woman Creek channel

downstream. Water in Pond C-2 was previously discharged to Woman Creek in accordance with the Plant NPDES permit (Discharge Point 007), but is not currently being discharged. Future plans call for a transfer of water from Pond C-2 to the South Walnut Creek Retention Pond B-5.

Flow in Woman Creek and the South Interceptor Ditch is intermittent; it appears and disappears along various reaches. During the 1986 initial site characterization, measurable flow occurred at less than one-half of the ten stations located along Woman Creek and the South Interceptor Ditch (Rockwell International 1986e). All recorded flows were less than ten gallons per minute. During the 1986 and 1987 investigations, there was no surface flow in Woman Creek downstream of Pond C-2. The intermittent surface water flow observed in Woman Creek and the South Interceptor Ditch may indicate groundwater inflow and outflow.

2.2 NATURE AND EXTENT OF CONTAMINATION

2.2.1 Introduction

The description of the nature and extent of contamination presented in this Subsection is based on data obtained from the Rocky Flats Environmental Database System (RFEDS) supplied by EG&G. Most of the data were presented in the Alluvial Work Plan, however, the RFEDS contains some data collected and/or validated since preparation of the Alluvial Work Plan. Background data discussed in Subsection 2.2.2 were taken from the draft Background Geochemical Characterization Report (EG&G 1990d).

Currently available validated bedrock analytical data are relatively few in number and are insufficient to draw definitive conclusions concerning the presence or absence of contamination. Validated data are identified in the data summary tables in this subsection by a V (validated and valid), an R (validated and rejected), or an A (validated and acceptable with qualifications). J indicates that data are present but below the detection limit. The code B refers to a blank sample.

Most of the available analytical data have not been validated. Only a few organic and metal sample results have been validated. Relatively high levels of several contaminants have been observed in the unvalidated data and occasionally in validated data. Most of the maximum contaminant levels identified in the bedrock are unvalidated, and therefore, the quality of these data is unknown but have been used for planning purposes. The unvalidated data have been included in this work plan and utilized for planning because, without the use of these data, there would be a very limited basis for making initial decisions, from a chemical contamination standpoint, in determining locations of wells and boreholes. Data collected during the Phase II RFI/RI alluvial and bedrock sampling efforts may provide some indication of the reliability of the unvalidated data.

Additional validated data from the first quarter of 1990 may be available in the near future and will be considered and evaluated when available.

2.2.2 Background Characterization

2.2.2.1 Introduction

To facilitate the interpretation of chemical results obtained during RFI/RIs, a background characterization program was implemented to define the spatial and temporal variability of naturally occurring constituents. Field work was conducted in 1989 and a draft Background Geochemical Characterization Report was prepared and submitted to the regulatory agencies on December 15, 1989 (Rockwell International 1989e). The report was recently finalized and Background Geochemical Characterization report issued in December 1990 (EG&G 1990d). These documents summarize the background data for groundwater, surface water, sediments, and geologic materials, and identifies statistical boundaries of background variability based on the available data. Spatial variations in the chemistry of geologic materials and water were addressed by sampling locations throughout background areas at the Plant. The sampling well locations were primarily in the Northern and Southern Buffer Zones of the Plant while groundwater flow for both the alluvial and bedrock systems is generally believed to be west to east (EG&G 1990d). The goal of evaluating temporal variations in water chemistry has not yet been achieved because a minimum of two years of quarterly data are needed. The background report is viewed as a living document which will continue to evolve as additional background data are collected. To date, the background geochemical characterization of the Plant has concentrated on the soil, bedrock and groundwater in the uppermost unconfined aquifer. However, for the purpose of site characterization, information in the Background Geochemical Characterization report (EG&G 1990d) has been used to preliminarily characterize inorganic contamination in Operable Unit 2 bedrock.

The boundary of background variability in the Background Geochemical Characterization Report was quantified through the calculation of tolerance intervals, assuming a normal distribution of values for each parameter analyzed. If a given constituent's concentration ranged over more than three orders of magnitude, a log normal tolerance was used; otherwise, a normal tolerance interval was used. The maximum detected value or the upper limit of the tolerance interval for each analyzed parameter in background groundwater, surface water, sediment, and geologic samples are provided in the Background Geochemical Characterization Report. Maximum detected values are provided and assumed to represent the maximum concentration for each naturally occurring chemical constituent where there were insufficient data to calculate tolerance intervals. This occurred when there was an insufficient number of samples or an insufficient number of detectable concentrations for a given chemical constituent. A summary of the upper limit of the tolerance interval or maximum detected value in groundwater for metals, other inorganics, and radionuclides is provided for the weathered claystone, the weathered sandstone, and the unweathered sandstone in Tables 2-2A through 2-2E, Tables 2-3A through 2-3D, and Tables 2-4A through 2-4E. Background information on the unweathered claystone is presently not available.

TABLE 2-2A

**STATISTICS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND WEATHERED
CLAYSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l)**

	Al	Sb	As	Ba	Be	Cd	Ca	Cs	Cr	Co	Cu	Fe	Pb	Li
Normal or Log Normal*	Normal	Normal	Normal	Normal	Normal	Normal	Log	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Upper Tolerance Limit							76.7449							
Lower Tolerance Limit														
Maximum Concentration	0.2U	0.5U	0.1U	0.2U	0.005U	0.005U	167.0	2.5U	0.02U	0.05U	0.477	0.0909	0.0049	0.4
Minimum Concentration	0.0405	0.06U	0.002U	0.05U	0.002U	0.004U	31.8	1.0U	0.01U	0.02U	0.025U	0.1U	0.003U	0.013U
Cohen or Unrevised	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Mean	0.0933	0.0575	0.0043	0.0953	0.0023	0.0024	58.8797	0.6406	0.0056	0.0230	0.0168	0.0549	0.0024	0.0753
Standard Deviation	0.0181	0.0751	0.0015	0.0188	0.0005	0.0002	7.0791	0.3023	0.0017	0.0053	0.0118	0.0130	0.0011	0.1062
Sample Size	15	16	16	16	16	15	16	16	16	15	16	15	14	16
Percent Detected	13.3	0.0	6.3	6.3	0.0	0.0	100.0	0.0	0.0	0.0	12.5	13.3	21.4	31.3
Classification Method	KA	KA	KA	KA	KA	KA	KA	A	KA	KA	KA	KA	KA	KA

	Mg	Mn	Hg	Mo	Ni	K	Se	Ag	Na	Sr	Tl	Sn	V	Zn
Normal or Log Normal*	Log	Log	Normal	Normal	Normal	Normal	Normal	Normal	Log	Normal	Normal	Normal	Normal	Normal
Upper Tolerance Limit	33.2559	0.4441							99.6049					0.1241
Lower Tolerance Limit														
Maximum Concentration	179.0	0.846	0.0008	0.5U	0.04U	5.31	0.9628	0.03U	714.0	7.12	0.05U	1.0U	0.05U	0.107
Minimum Concentration	5.15	0.015U	0.0002U	0.015U	0.02U	1.72	0.005U	0.01U	13.4	0.198	0.003U	0.1U	0.01U	0.02U
Cohen or Unrevised	UN	C	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	C
Mean	20.0602	0.1723	0.0002	0.0677	0.0183	2.6393	0.0095	0.0063	57.0263	0.8971	0.0059	0.1344	0.0225	0.0259
Standard Deviation	5.2288	0.1077	0.0002	0.0728	0.0039	0.7661	0.0171	0.0034	16.8718	1.6735	0.0053	0.1814	0.0068	0.0567
Sample Size	16	16	16	16	12	15	15	16	16	16	16	16	16	13
Percent Detected	100.0	68.8	25.0	12.5	0.0	20.0	20.0	0.0	100.0	43.8	6.3	0.0	0.0	69.2
Classification Method	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.
U = Concentration below detection limit.

M = MANOVA

. = Value not computed.

C = Cohen revised statistics

UN = Unrevised statistics

A = Parametric ANOVA.

K = Kruskal-Wallis nonparametric ANOVA.

- = No classification.

P = Test of proportions.

TABLE 2-2B

**STATISTICS FOR INORGANIC CONCENTRATIONS IN BACKGROUND
NORTH ROCKY FLATS WEATHERED CLAYSTONE GROUNDWATER SAMPLES
(CONCENTRATION UNITS mg/l EXCEPT pH)**

	HCO ₃	CO ₃	Cl	CN	Field pH	NO ₃ /NO ₂	SO ₄
Normal or Log Normal*			Log				
Upper Tolerance Limit
Lower Tolerance Limit
Maximum Concentration			4.0				
Minimum Concentration			3.0U				
Cohen or Unrevised			UN				
Mean	.	.	1.8872	.	.	.	.
Standard Deviation	.	.	0.3083	.	.	.	.
Sample Size			6				
Percent Detected			16.7				
Classification Method			-				

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U = Concentration below detection limit.

M = MANOVA.

. = Value not computed.

C = Cohen revised statistics.

UN = Unrevised statistics.

A = Parametric ANOVA.

K = Kruskal-Wallis nonparametric ANOVA.

- = No classification.

P = Test of proportions.

TABLE 2-2C

**STATISTICS FOR INORGANIC CONCENTRATIONS IN BACKGROUND
WEATHERED CLAYSTONE GROUNDWATER SAMPLES
(CONCENTRATION UNITS mg/l EXCEPT pH)**

	HCO ₃	CO ₃	Cl	CN	Field pH	NO ₃ /NO ₂	SO ₄
Normal or Log Normal*	Log	Normal		Normal	Normal	Log	Log
Upper Tolerance Limit	298.4996	.	.	.	8.6888	0.6143	49.3145
Lower Tolerance Limit	.	.	.	.	6.6168	.	.
Maximum Concentration	400.0	5.0U		0.01U	8.4	0.66	100.0
Minimum Concentration	144.0	5.0U		0.0025U	7.0	0.05U	11.0
Cohen or Unrevised	UN	UN		UN	UN	UN	UN
Mean	235.7107	2.5000	.	0.0033	7.6528	0.3413	33.4302
Standard Deviation	22.9463	0.0000	.	0.0019	0.4223	0.1022	5.8049
Sample Size	12	12		14	18	13	12
Percent Detected	100.0	0.0		7.1	100.0	92.3	100.0
Classification Method	A	-		-	KA	KA	KA

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U = Concentration below detection limit.

M = MANOVA.

. = Value not computed.

C = Cohen revised statistics.

UN = Unrevised statistics.

A = Parametric ANOVA.

K = Kruskal-Wallis nonparametric ANOVA.

- = No classification.

P = Test of proportions.

TABLE 2-2D

**STATISTICS FOR INORGANIC CONCENTRATIONS IN BACKGROUND
SOUTH ROCKY FLATS WEATHERED CLAYSTONE GROUNDWATER SAMPLES
(CONCENTRATION UNITS mg/l EXCEPT pH)**

	HCO ₃	CO ₃	Cl	CN	Field pH	NO ₃ /NO ₂	SO ₄
Normal or Log Normal*			Log				
Upper Tolerance Limit
Lower Tolerance Limit
Maximum Concentration			26.0				
Minimum Concentration			3.0U				
Cohen or Unrevised			C				
Mean	.	.	12.4599	.	.	.	.
Standard Deviation	.	.	5.1094	.	.	.	.
Sample Size			6				
Percent Detected			83.3				
Classification Method							

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U = Concentration below detection limit.

M = MANOVA.

. = Value not computed.

C = Cohen revised statistics.

UN = Unrevised statistics.

A = Parametric ANOVA.

K = Kruskal-Wallis nonparametric ANOVA.

- = No classification.

P = Test of proportions.

TABLE 2-2E

STATISTICS FOR DISSOLVED RADIOCHEMICAL CONCENTRATIONS IN BACKGROUND WEATHERED CLAYSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS pCi/l)

	Am241	Cs137	Alpha	Beta	Po239	Ra226	Ra228	Sr90	Tritium	U233,234	U235	U238
Normal or Log Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Upper Tolerance Limit	0.0347	0.3916	24.9638	13.2977	0.0305			0.6422	291.8227		0.3693	5.2006
Lower Tolerance Limit												
Maximum Concentration	0.034	0.4	24.0	12.0	0.03	0.7		0.44	300.0		0.28	4.68
Minimum Concentration	0.0	-0.2	0.0	2.2	0.0	0.29		-0.3	-100.0		0.0	0.4
Cohen or Unevalued	UN	UN	UN	UN	UN	UN		UN	UN		UN	UN
Mean	0.0034	0.1046	7.7000	5.4846	0.0044	0.4817		0.0462	40.8421		0.1140	1.9533
Standard Deviation	0.0108	0.1824	6.4721	2.9257	0.0093	0.1497		0.2232	103.5810		0.0995	1.2655
Sample Size	10	13	13	13	11	6		13	19		15	15
Percent Detected	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0		100.0	100.0
Classification Method	KA	A	KA	KA	KA	KA		KA	A		KA	KA

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U = Concentration below detection limit.

M = MANOVA.

. = Value not computed.

C = Cohen revised statistics.

UN = Unevalued statistics.

A = Parametric ANOVA.

K = Kruskal-Wallis nonparametric ANOVA.

- = No classification.

P = Test of proportions.

TABLE 2-3A

**STATISTICS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND WEATHERED
SANDSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l)**

	Al	Sb	As	Ba	Be	Cd	Cs	Co	Cr	Cu	Fe	Pb	Li
Normal or Log Normal*	Normal	Normal	Normal	Normal	Normal	Normal	Log	Normal	Normal	Normal	Normal	Normal	Normal
Upper Tolerance Limit													
Lower Tolerance Limit													
Maximum Concentration	0.2U	0.176	0.01U	0.2U	0.005U	0.005U	65.7	0.0122	0.0122	0.025U	0.1U	0.005U	1.79
Minimum Concentration	0.2U	0.06U	0.01U	0.2U	0.005U	0.005U	30.9	0.01U	0.01U	0.025U	0.1U	0.005U	0.0106
Cohen or Unrevised	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Mean	0.1000	0.0665	0.0050	0.1000	0.0025	0.0025	46.0332	0.0064	0.0064	0.0125	0.0500	0.0025	0.3334
Standard Deviation	0.0000	0.0730	0.0000	0.0000	0.0000	0.0000	5.8860	0.0032	0.0032	0.0000	0.0000	0.0000	0.7137
Sample Size	6	4	4	5	4	5	6	5	5	5	6	5	6
Percent Detected	0.0	25.0	0.0	0.0	0.0	0.0	100.0	20.0	20.0	0.0	0.0	0.0	33.3
Classification Method	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA

	Mg	Mn	Hg	Mo	Ni	K	Se	Ag	Na	Sr	Tl	V	Zn
Normal or Log Normal*	Log	Log	Normal	Normal	Normal	Normal	Normal	Normal	Log	Normal	Normal	Normal	Normal
Upper Tolerance Limit													
Lower Tolerance Limit													
Maximum Concentration	9.41	0.292	0.0002U	0.1U		10.2	0.005U	0.01U	25.6	2.03	0.05U	0.05U	0.0258
Minimum Concentration	5.25	0.015U	0.0002U	0.015	0.04U	5.08	0.005U	0.01U	12.6	0.288	0.01U	0.05U	0.02U
Cohen or Unrevised	UN	C	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Mean	7.3261	0.1124	0.0001	0.0442	0.0200	4.0400	0.0025	0.0050	20.4354	0.7197	0.0083	0.0250	0.0126
Standard Deviation	0.7506	0.0722	0.0000	0.0143	0.0000	3.4435	0.0000	0.0000	2.6519	0.6475	0.0082	0.0000	0.0065
Sample Size	6	6	5	6	6	5	4	5	6	6	6	6	6
Percent Detected	100.0	83.3	0.0	16.7	0.0	20.0	0.0	0.0	100.0	33.3	0.0	0.0	16.7
Classification Method	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U = Concentration below detection limit.

M = MANOVA

. = Value not computed.

C = Cohen revised statistics

UN = Unrevised statistics.

A = Parametric ANOVA.

K = Kruskal-Wallis nonparametric ANOVA.

- = No classification.

P = Test of proportions.

TABLE 2-3B

**STATISTICS FOR INORGANIC CONCENTRATIONS IN BACKGROUND
WEATHERED SANDSTONE GROUNDWATER SAMPLES
(CONCENTRATION UNITS mg/l EXCEPT pH)**

	HCO ₃	CO ₃	Cl	CN	Field pH	NO ₃ /NO ₂	SO ₄
Normal or Log Normal*	Log	Normal		Normal	Normal	Log	Log
Upper Tolerance Limit	236.8072	.	.	.	8.8076	2.1648	39.1245
Lower Tolerance Limit	.	.	.	.	5.6674	.	.
Maximum Concentration	240.0	5.0U		0.01U	8.4	1.6	48.0
Minimum Concentration	130.0	5.0U		0.0025U	6.9	0.18	13.0
Cohen or Unrevised	UN	UN		UN	UN	UN	UN
Mean	175.5991	2.5000		0.0025	7.2375	0.9473	23.7154
Standard Deviation	18.0052	0.0000		0.0019	0.4926	0.3581	4.5328
Sample Size	7	7		6	8	7	7
Percent Detected	100.0	0.0		0.0	100.0	100.0	100.0
Classification Method	-	-		-	-	-	-

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U = Concentration below detection limit.

M = MANOVA.

. = Value not computed.

C = Cohen revised statistics.

UN = Unrevised statistics.

A = Parametric ANOVA.

K = Kruskal-Wallis nonparametric ANOVA.

- = No classification.

P = Test of proportions.

TABLE 2-3C

**STATISTICS FOR INORGANIC CONCENTRATIONS IN BACKGROUND
SOUTH ROCKY FLATS WEATHERED SANDSTONE GROUNDWATER SAMPLES
(CONCENTRATION UNITS mg/l EXCEPT pH)**

	HCO ₃	CO ₃	Cl	CN	Field pH	NO ₃ /NO ₂	SO ₄
Normal or Log Normal*			Log				
Upper Tolerance Limit	.	.	17.2107	.	.	.	.
Lower Tolerance Limit
Maximum Concentration			18.0				
Minimum Concentration			6.0				
Cohen or Unrevised			UN				
Mean	.	.	10.2500	.	.	.	.
Standard Deviation	.	.	2.0476	.	.	.	.
Sample Size			7				
Percent Detected			100.0				
Classification Method			-				

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U = Concentration below detection limit.

M = MANOVA.

. = Value not computed.

C = Cohen revised statistics.

UN = Unrevised statistics.

A = Parametric ANOVA.

K = Kruskal-Wallis nonparametric ANOVA.

- = No classification.

P = Test of proportions.

TABLE 2-3D

**STATISTICS FOR DISSOLVED RADIOCHEMICAL CONCENTRATIONS IN BACKGROUND WEATHERED
SANDSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS pCi/l)**

	Am241	Cs137	Alpha	Beta	Pu239	Ra226	Ra228	Sr90	Tritium	U233,234	U235	U238
Normal or Log Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Upper Tolerance Limit	0.0263	0.9777	12.7000	5.6214	0.0159			0.9394	235.1185		0.2170	1.0706
Lower Tolerance Limit	0.016	0.3	8.0	4.0	0.01			0.52	100.0		0.13	0.62
Maximum Concentration	0.0	-0.5	0.7	0.0	0.0			-0.2	-100.0		-0.07	0.1
Minimum Concentration	UN	UN	UN	UN	UN		UN	UN	UN	UN	UN	UN
Cohen or Unrevised												
Mean	0.0046	-0.0313	3.9125	1.9250	0.0030	0.3667		0.1125	1.2500		0.0188	0.3900
Standard Deviation	0.0064	0.3166	2.7570	1.1597	0.0040	0.0577		0.2594	73.3753		0.0022	0.2261
Sample Size	7	8	8	8	8	3		8	8		8	8
Percent Detected	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0		100.0	100.0
Classification Method	KA	KA	KA	KA	KA	KA	KA	KA	A	KA	KA	KA

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U = Concentration below detection limit.

M = MANOVA.

. = Value not computed.

C = Cohen revised statistics.

UN = Unrevised statistics.

A = Parametric ANOVA.

K = Kruskal-Wallis nonparametric ANOVA.

- = No classification.

P = Test of proportions.

TABLE 2-4A

**STATISTICS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND UNWEATHERED
SANDSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l)**

	Al	Sb	As	Ba	Be	Cd	Ca	Co	Cr	Cu	Fe	Pb	Li
Normal or Log Normal*	Normal	Normal	Normal	Normal	Normal	Normal	Log	Normal	Normal	Normal	Normal	Normal	Normal
Upper Tolerance Limit							38.8630						
Lower Tolerance Limit													
Maximum Concentration	0.327	0.31	0.0186	0.21	0.0031	0.0031	99.3	2.51	0.0177	0.0695	0.0539	0.024	0.283
Minimum Concentration	0.031	0.061	0.0021	0.051	0.0021	0.0041	5.01	0.11	0.011	0.021	0.0336	0.0021	0.024
Cohen or Unbiased	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Mean	0.1109	0.0647	0.0055	0.0947	0.0023	0.0024	24.4479	0.4925	0.0067	0.0228	0.0166	0.0489	0.0624
Standard Deviation	0.0690	0.0624	0.0036	0.0171	0.0006	0.0002	6.0163	0.2255	0.0035	0.0055	0.0043	0.0059	0.0538
Sample Size	13	19	20	20	18	17	20	20	16	20	19	20	20
Percent Detected	7.7	0.0	15.0	18.0	0.0	0.0	50.0	0.0	6.3	10.5	15.8	10.0	25.0
Classification Method	KA	KA	KA	KA	KA	KA	KA	A	KA	KA	KA	KA	KA

	Mg	Mn	Hg	Mo	Ni	K	Se	Ag	Na	Sr	Ti	V	Zn
Normal or Log Normal*	Log	Log	Normal	Normal	Normal	Normal	Normal	Normal	Log	Normal	Normal	Normal	Normal
Upper Tolerance Limit									213.3108				0.2582
Lower Tolerance Limit													
Maximum Concentration	35.0	0.0774	0.0003	0.51	0.041	21.9	0.041	0.031	454.0	1.43	0.041	0.051	0.374
Minimum Concentration	1.91	0.011	0.00021	0.11	0.021	5.01	0.0021	0.011	61.7	0.139	0.0031	0.011	0.021
Cohen or Unbiased	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Mean	4.2178	0.0167	0.0001	0.0659	0.0182	5.9247	0.0062	0.0066	155.9665	0.5638	0.0063	0.1175	0.0440
Standard Deviation	0.7074	0.0035	0.0001	0.0730	0.0039	6.0886	0.0094	0.0037	23.9334	0.2775	0.0050	0.0079	0.0661
Sample Size	20	19	19	20	17	19	19	19	20	20	19	20	17
Percent Detected	35.0	31.6	26.3	10.0	0.0	47.4	31.6	0.0	100.0	40.0	0.0	0.0	56.8
Classification Method	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.
 U = Concentration below detection limit.

M = MANOVA

. = Value not computed.

C = Cohen revised statistics

UN = Unbiased statistics

A = Parametric ANOVA.

K = Kruskal-Wallis nonparametric ANOVA.

= No classification.

P = Test of proportions.

TABLE 2-4B

**STATISTICS FOR INORGANIC CONCENTRATIONS IN BACKGROUND
NORTH ROCKY FLATS WEATHERED CLAYSTONE GROUNDWATER SAMPLES
(CONCENTRATION UNITS mg/l EXCEPT pH)**

	HCO ₃	CO ₃	Cl	CN	Field pH	NO ₃ /NO ₂	SO ₄
Normal or Log Normal*	Log	Normal		Normal	Normal	Log	Log
Upper Tolerance Limit	302.2308	30.1793	.	.	10.6483	.	290.9021
Lower Tolerance Limit	.	.	.	.	7.2917	.	.
Maximum Concentration	390.0	25.0	.	0.01U	10.4	3.6	670.0
Minimum Concentration	140.0	5.0U	.	0.0025U	8.0	0.05U	5.0U
Cohen or Unrevised	UN	C	.	UN	UN	C	C
Mean	255.6284	6.3774	.	0.0037	8.9700	0.7294	88.9962
Standard Deviation	17.4508	8.9129	.	0.0017	0.7005	0.6543	75.6059
Sample Size	13	13	.	1	20	12	13
Percent Detected	100.0	69.2	.	18.2	100.0	50.0	61.5
Classification Method	A	-	.	-	KA	-	-

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values. U = Concentration below detection limit. M = MANOVA.
 . = Value not computed. C = Cohen revised statistics. UN = Unrevised statistics. A = Parametric ANOVA. K = Kruskal-Wallis nonparametric ANOVA. - = No classification. P = Test of proportions.

TABLE 2-4B

**STATISTICS FOR INORGANIC CONCENTRATIONS IN BACKGROUND
NORTH ROCKY FLATS WEATHERED CLAYSTONE GROUNDWATER SAMPLES
(CONCENTRATION UNITS mg/l EXCEPT pH)
(Continued)**

	HCO ₃	CO ₃	Cl	CN	Field pH	NO ₃ /NO ₂	SO ₄
Normal or Log Normal*			Log				
Upper Tolerance Limit
Lower Tolerance Limit
Maximum Concentration			230.0				
Minimum Concentration			4.0				
Cohen or Unrevised			UN				
Mean	.	.	23.8698	.	.	.	.
Standard Deviation	.	.	14.1990	.	.	.	.
Sample Size			6				
Percent Detected			100.0				
Classification Method							

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values. U = Concentration below detection limit. M = MANOVA.
 . = Value not computed. C = Cohen revised statistics. UN = Unrevised statistics. A = Parametric ANOVA. K = Kruskal-Wallis nonparametric ANOVA. _ = No classification. P = Test of proportions.

TABLE 2-4B

**STATISTICS FOR INORGANIC CONCENTRATIONS IN BACKGROUND
NORTH ROCKY FLATS WEATHERED CLAYSTONE GROUNDWATER SAMPLES
(CONCENTRATION UNITS mg/l EXCEPT pH)
(Continued)**

	HCO ₃	CO ₃	Cl	CN	Field pH	NO ₃ /NO ₂	SO ₄
Normal or Log Normal*			Log				
Upper Tolerance Limit	.	.	412.3540	.	.	.	.
Lower Tolerance Limit
Maximum Concentration			260.0				
Minimum Concentration			6.0				
Cohen or Unrevised			UN				
Mean	.	.	159.6799	.	.	.	.
Standard Deviation	.	.	74.3275	.	.	.	.
Sample Size			7				
Percent Detected			100.0				
Classification Method							

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values. U = Concentration below detection limit. M = MANOVA.
 . = Value not computed. C = Cohen revised statistics. UN = Unrevised statistics. A = Parametric ANOVA. K = Kruskal-Wallis nonparametric ANOVA. _ = No classification. P = Test of proportions.

TABLE 2-4C

**STATISTICS FOR INORGANIC CONCENTRATIONS IN BACKGROUND
NORTHERN ROCKY FLATS UNWEATHERED SANDSTONE GROUNDWATER
SAMPLES
(CONCENTRATION UNITS mg/l EXCEPT pH)**

	HCO ₃	CO ₃	Cl	CN	Field pH	NO ₃ /NO ₂	SO ₄
Normal or Log Normal*			Log				
Upper Tolerance Limit
Lower Tolerance Limit
Maximum Concentration			230.0				
Minimum Concentration			4.0				
Cohen or Unrevised			UN				
Mean	.	.	23.8698	.	.	.	.
Standard Deviation	.	.	14.1990	.	.	.	.
Sample Size			6				
Percent Detected			100.0				
Classification Method			-				

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U = Concentration below detection limit.

M = MANOVA.

. = Value not computed.

C = Cohen revised statistics.

UN = Unrevised statistics.

A = Parametric ANOVA.

K = Kruskal-Wallis nonparametric ANOVA.

- = No classification.

P = Test of proportions.

TABLE 2-4D

**STATISTICS FOR INORGANIC CONCENTRATIONS IN BACKGROUND
SOUTH ROCKY FLATS UNWEATHERED SANDSTONE GROUNDWATER SAMPLES
(CONCENTRATION UNITS mg/l EXCEPT pH)**

	HCO ₃	CO ₃	Cl	CN	Field pH	NO ₃ /NO ₂	SO ₄
Normal or Log Normal*			Log				
Upper Tolerance Limit	.	.	412.3540	.	.	.	.
Lower Tolerance Limit
Maximum Concentration			260.0				
Minimum Concentration			6.0				
Cohen or Unrevised			UN				
Mean	.	.	159.6799	.	.	.	.
Standard Deviation	.	.	74.3275	.	.	.	.
Sample Size			7				
Percent Detected			100.0				
Classification Method							

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.
 U = Concentration below detection limit.
 M = MANOVA.
 . = Value not computed.
 C = Cohen revised statistics.
 UN = Unrevised statistics.
 A = Parametric ANOVA.
 K = Kruskal-Wallis nonparametric ANOVA.
 - = No classification.
 P = Test of proportions.

TABLE 2-4E

**STATISTICS FOR DISSOLVED RADIOCHEMICAL CONCENTRATIONS IN BACKGROUND UNWEATHERED
SANDSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS pCi/l)**

	Am241	Cs137	Alpha	Beta	Pb210	Ra226	Ra228	Sr90	Tritium	U233,234	U235	U238
Normal or Log Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Upper Tolerance Limit	0.0636	0.8192	28.4866	33.4236	0.0109			0.9283	495.8059		1.0681	7.0858
Lower Tolerance Limit												
Maximum Concentration	0.062	0.85	38.9	43.8	0.01	0.6		1.0	340.0		1.7	11.59
Minimum Concentration	0.0	-0.3	-4.0	2.0	-0.002	0.2		-0.3	-400.0		0.0	-0.1
Cohen or Unrevised	UN	UN	UN	UN	UN	UN		UN	UN		UN	UN
Mean	0.0091	0.1040	5.4947	10.0800	0.0023	0.4000		0.1650	-25.0000		0.1580	1.0135
Standard Deviation	0.0213	0.2985	9.4889	9.7427	0.0036	0.2828		0.3186	217.3646		0.3799	2.5343
Sample Size	15	20	19	20	19	2		20	20		20	20
Percent Detected	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0		100.0	100.0
Classification Method	KA	A	KA	KA	KA			KA	A		KA	KA

* = Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U = Concentration below detection limit.

M = MANOVA.

. = Value not computed.

C = Cohen revised statistics.

UN = Unrevised statistics.

A = Parametric ANOVA.

K = Kruskal-Wallis nonparametric ANOVA.

- = No classification.

P = Test of proportions.

2.2.2.2 Organics

Background samples were not analyzed for EPA Contract Laboratory Program (CLP) Target Compound List (TCL) organics because organics are assumed not to be present in background areas. Validated results of a sample analysis that are above the method detection limit will be considered to represent potential contamination, and additional data will be collected at that location (i.e., resampling) to evaluate whether the groundwater is actually contaminated at that location or if the analysis results may contain lab errors or artifacts.

2.2.2.3 Inorganics

To assess the presence of inorganic contamination in Operable Unit 2, site-specific chemical data will be compared to the background tolerance intervals or the maximum detected value determined in the Background Geochemical Characterization Report. A constituent concentration that is greater than the maximum detected background value and/or the upper limit value of the one-sided 95 percent tolerance interval at the 95 percent confidence level value will preliminarily be considered to represent contamination. This approach provides adequate information for borehole and monitoring well placement plans. Since the 95 percent confidence level is being utilized, it can be expected that approximately 5 percent of the time, constituent concentrations will be found to exceed the upper tolerance level even when contamination is not present. Therefore, resampling will be necessary to confirm the presence of contamination when the upper tolerance level is exceeded.

Available background information on the weathered claystone, weathered sandstone, and unweathered sandstone is provided for inorganics in Tables 2-2A, 2-3A, and 2-4A (metals), and 2-2B, 2-2C, 2-2D, 2-3B, 2-3C, 2-3D, 2-4B, 2-4C, and 2-4D (non-metallic inorganics). Tables 2-5A, 2-5B, and 2-5C provide information on well designations and lithologies screened by the wells. The background data generally indicate that uncontaminated groundwater within the deeper confined sandstones can be distinguished from that in the unconfined sandstones and alluvium by the presence of higher concentrations of sodium, sulfate, chloride, and total dissolved solids in water within the deeper confined sandstones. Comparison of concentrations in the Operable Unit 2 groundwater with ARARs is presented in Section 3.0.

Background information on the unweathered claystone would be useful in assessing the presence or absence of contamination for inorganic species in the unweathered claystone within Operable Unit 2; however, no background information on the unweathered claystone is available. The primary contaminants identified in the upper hydrostratigraphic unit (HSU) [the volatile organic species carbon tetrachloride (CCl_4), tetrachloroethylene (PCE), and trichloroethylene (TCE)] are the contaminants that are mobile and, therefore, most likely to migrate into the lower HSU(s). Therefore, volatile organic contaminants are believed to have a greater potential to be present in the lower HSU(s) than inorganic contaminants.

TABLE 2-5A**SUMMARY OF WELLS USED FOR BACKGROUND
CONCENTRATIONS OF DISSOLVED METALS**

Well Designation	Screened Formation
B203189	KCL
B203289	KCL
B203489	KCL
B203589	KCL
B203689	KCL
B304889	KCL
B305389	KCL
B405489	KCL
B203789	KSSU
B203889	KSSU
B203989	KSSU
B204089	KSSU
B204189	KSSU
B304289	KSSU
B304989	KSSU
B405289	KSSU
B402189	KSSW
B405889	KSSW
B201189	QC
B201289	QC
B205589	QC
B302089	QC
B401989	QC
B200589	QRF
B200689	QRF
B200789	QRF
B200889	QRF
B400189	QRF
B400289	QRF
B400389	QRF
B400489	QRF
B405586	QRF
B405689	QRF

TABLE 2-5A

**SUMMARY OF WELLS USED FOR BACKGROUND
CONCENTRATIONS OF DISSOLVED METALS
(Continued)**

Well Designation	Screened Formation
B405789	QRF
B102289	QVF
B102389	QVF
B202489	QVF
B202589	QVF
B302789	QVF
B302889	QVF
B302989	QVF
B402689	QVF

KCL = Weathered Claystone
 KSSU = Unweathered Sandstone
 KSSW = Weathered Sandstone
 QC = Colluvium
 QRF = Rocky Flats Alluvium
 QVF = Valley Fill Alluvium

TABLE 2-5B

**SUMMARY OF WELLS USED FOR BACKGROUND
CONCENTRATIONS OF INORGANICS**

Well Designation	Screened Formation
B203189	KCL
B203289	KCL
B203489	KCL
B203589	KCL
B203689	KCL
B304889	KCL
B305389	KCL
B405489	KCL
B203789	KSSU
B203889	KSSU
B203989	KSSU
B204089	KSSU
B204189	KSSU
B304289	KSSU
B304989	KSSU
B405289	KSSU
B402189	KSSW
B405889	KSSW
B201189	QC
B201289	QC
B205589	QC
B302089	QC
B401989	QC
B200589	QRF
B200689	QRF
B200789	QRF
B200889	QRF
B400189	QRF
B400289	QRF
B400389	QRF
B400489	QRF
B405586	QRF
B405689	QRF
B405789	QRF

TABLE 2-5B

**SUMMARY OF WELLS USED FOR BACKGROUND
CONCENTRATIONS OF INORGANICS
(Continued)**

Well Designation	Screened Formation
B102289	QVF
B102389	QVF
B202489	QVF
B202589	QVF
B302789	QVF
B302889	QVF
B302989	QVF
B303089	QVF
B402689	QVF

KCL = Weathered Claystone
 KSSU = Unweathered Sandstone
 KSSW = Weathered Sandstone
 QC = Colluvium
 QRF = Rocky Flats Alluvium
 QVF = Valley Fill Alluvium

TABLE 2-5C**SUMMARY OF WELLS USED FOR BACKGROUND
EVALUATION OF GROUNDWATER RADIOCHEMISTRY**

Well Designation	Screened Formation
B203189	KCL
B203289	KCL
B203489	KCL
B203589	KCL
B203689	KCL
B304889	KCL
B305389	KCL
B405489	KCL
B203789	KSSU
B203889	KSSU
B203989	KSSU
B204089	KSSU
B204189	KSSU
B304289	KSSU
B304989	KSSU
B405289	KSSU
B402189	KSSW
B405889	KSSW
B201189	QC
B201289	QC
B205589	QC
B401989	QC
B200589	QRF
B200689	QRF
B200789	QRF
B200889	QRF
B400189	QRF
B400289	QRF
B400389	QRF
B400489	QRF
B405586	QRF
B405689	QRF
B405789	QRF

TABLE 2-5C

**SUMMARY OF WELLS USED FOR BACKGROUND
EVALUATION OF GROUNDWATER RADIOCHEMISTRY
(Continued)**

Well Designation	Screened Formation
B102289	QVF
B102389	QVF
B202489	QVF
B202589	QVF
B302789	QVF
B302889	QVF
B302989	QVF
B402689	QVF

KCL = Weathered Claystone
 KSSU = Unweathered Sandstone
 KSSW = Weathered Sandstone
 QC = Colluvium
 QRF = Rocky Flats Alluvium
 QVF = Valley Fill Alluvium

2.2.2.4 Radionuclides

Radionuclides are analyzed by counting sub-atomic particle emissions. Since the counting of radioactive disintegration is a process that may be evaluated statistically using a probability distribution, results are reported as a measured value with an associated two standard deviation propagated counting error term indicated in parentheses immediately following the measured value. For the purposes of this plan, the boundaries of the background range for radionuclides will be the tolerance interval values presented in the Background Geochemical Characterization Report and contained in Tables 2-2E, 2-3D, and 2-4E. However, it should be noted that the computation of tolerance intervals for radionuclides did not account for the error term associated with each analysis value reported. Site radionuclide concentrations below the minimum detectable activity (MDA) are considered background. Also, concentrations where the error term is larger than the measured value are considered below the MDA and are therefore considered not statistically different from background. Measured values that exceed their associated counting errors and are above the upper limit of the calculated tolerance interval value are considered to be above background. Because this comparison does not account for the propagated error associated with the upper limit of the background tolerance interval, this method is a conservative means of interpreting the site data. It is also noted that the upper limits of the tolerance intervals are similar in magnitude to the maximum concentration observed for the background data set.

2.2.3 Groundwater

The 903 Pad, Mound, and East Trenches areas, located on the east side of the Rocky Flats Plant security area, were selected for investigation because of their suspected relationship to groundwater contamination. Based on existing results, CCl₄, PCE, and TCE are the primary volatile organic contaminants found in the upper HSU at these areas. Trace elements occasionally exceeding background levels in the upper HSU include barium, copper, nickel, manganese, and zinc. Also, major anions and total dissolved solids are elevated above background in the upper HSU throughout and downgradient of the 903 Pad, Mound, and East Trenches areas. Radionuclide levels are generally within the tolerance limits for the background groundwater data, but a few samples indicate minimum detectable amounts of plutonium and americium in the vicinity of the 903 Pad and possibly north of the Mound.

There are 20 wells in the 903 Pad, Mound, and East Trenches areas that are screened entirely with depth intervals believed to represent the lower (bedrock) HSU(s) (i.e., below the conceptual boundary shown in Figure 1-1). Analytical data are available for twelve of these wells. Of these twelve lower-HSU wells with analytical data, one of them, Well 1487BR, may be more representative of upper HSU groundwater chemistry since it is screened in weathered, subcropping Arapahoe Sandstone No. 5 at relatively shallow depth. Similarly, Wells 1287BR and 6286 are screened entirely in bedrock but are probably more representative of groundwater chemistry of the upper HSU than of the lower HSU. They are both relatively shallow and have the tops of their screens 1.5 to 3 feet below the bedrock surface. These two wells are

considered to be upper HSU wells since they are not entirely screened more than 5 feet into the bedrock. Samples collected from these wells contain various concentrations of organic, inorganic and radioactive constituents. The screened intervals for these wells range from relatively shallow (Well 1487BR, 19-24 feet) to relatively deep (Well 2887 BR, 187-197 feet). Although the currently available bedrock groundwater data is limited, it generally appears that contamination in the deeper zones of bedrock are in the same general areas as the maximum contaminant concentrations in the upper HSU (i.e., the area east of the 903 Pad, the area southeast and east of the Mound Area, and the East Trenches Area).

Areas where concentrations of contaminants in the upper HSU were relatively low or not present also tended to have lower or non-detectable levels of contaminants in the lower HSU. Figures 2-21 through 2-23 show plumes identified by the Phase I RI for the primary organic contaminants in the upper HSU.

2.2.3.1 Organic Compounds

Most of the validated groundwater analytical results for detected volatile organic compounds in the lower HSU(s) are below or only slightly higher than the reporting limits required by the EPA Contract Laboratory Program (CLP). In many cases the detected organics are also common laboratory contaminants that appeared in the laboratory method blanks. However, higher levels of several organic contaminants, such as trichloroethane (TCA) and TCE, have been identified in the unvalidated results (Table 2-6).

Samples collected from Well 3687BR, which is screened in the Arapahoe Sandstone No. 1 and located northeast of IHSS 111.1, contained 1,1-dichloroethylene (1,1-DCE); 1,2-dichloroethylene (1,2-DCE); 2-hexanone; 1,1,-trichloroethane, and toluene. 1,1-DCE was also reported in Well 1587 and 1,2-DCE was reported on one occasion in Well 2587BR. Only four wells screened in depth intervals believed to represent the lower HSU(s) were found to contain volatile organic compounds. These results are unvalidated. PCE was found in wells 1887BR and 2087BR, both of which are screened in lower sandstones. The concentrations were 16 $\mu\text{g/l}$ in Well 1887BR, screened in the Arapahoe Formation Sandstone No. 4, and as high as 140 $\mu\text{g/l}$ in well 2087BR screened in the Arapahoe Formation Sandstone No. 3. These two wells are located in the eastern portion of the Mound Area. Less than 10 $\mu\text{g/l}$ of methylene chloride was measured in Well 3487BR, and 18 $\mu\text{g/l}$ of TCE was measured in well 4086. Both of these wells are screened in unweathered claystone in the east portion of the East Trenches Area.

Well 1487BR is considered a lower-HSU well by the criteria used to distinguish the upper from the lower HSU in this work plan. However, as discussed above in Subsection 2.2.3, analytical chemistry results from this well may not be representative of the lower HSU groundwater chemistry since it is screened in

TABLE 2-6

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs

Well Designation	Lithology of Screened Interval ^(a)	Analytical Data Availability ^(a)	Sample Date ^(a)	Volatile Organic Compounds Detected (µg/l)											
				Carbon Tetrachloride	Chloroform	Acetone	1,1-DCE	1,2-DCE	2-Hexanone	1,1,1-TCA	Methylene Chloride	Toluene	TCE	PCE	Carbon Disulfide
UPPER HSU															
1387	AL	Y	09/10/87(3)	4080										510	900
			02/29/88(1)	1591	35						8		96	212	
			04/20/88(2)	4305	42								269	782	
			05/01/89(2)	11003	21								120	190	
			08/02/89(3)	1200	36					2J			110	200	
1287BR	CS	Y	08/31/87(3)	58	33								3750	43	
			02/25/88(1)	20	17						9		547	34	
			04/20/88(2)	43	17								751	57	
			11/14/89(4)										310		
			11/20/89(4)										310		
2587BR	SSM	Y	9/10/87(3)	61	18								56	320	
			10/21/87(4)	75									42	528	
			3/3/88(1)	110	41								83	598	
			2/15/89(1)	180										360	
			5/8/92(2)	290	51								120	840	
3687BR	SSM/CS	Y	8/17/89(3)	110	31								92	330	
			11/2/89(4)	120	31								86	440	
			11/5/87(3)	3673	5427	38	1044		28	1472	119	53	118298	4654	
			3/9/88(1)	545	1370				975				131820		
			5/4/88(2)		2810	11	230						221860	2450	
2387BR	SSM	Y	11/10/88(4)	1611	486								2451	396	
			2/15/89(1)	620			506	92		8			49000	260	
			5/8/89(3)				32			63					
			11/10/89(4)	610	290E		22J					2J	12000	350E	
						03/02/88(1)								18000	
			5/9/88(2)											19	

TABLE 2-6
SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUS
(Continued)

Well Designation	Lithology of Screened Interval ^(a)	Analytical Data Availability ^(b)	Sample Date ^(c)	Volatile Organic Compounds Detected (ug/l)										
				Carbon Tetrachloride	Chloroform	Acetone	1,1-DCE	1,2-DCE	2-Hexanone	1,1,1-TCA	Methylene Chloride	Toluene	TCE	PCE	Carbon Disulfide
UPPER HSU														
486	CS	Y	01/03/89(1)		3BA							6BA		3/A
			02/07/89(1)		2/A									
			08/07/89(3)	U										U
			12/04/89(4)											
			11/16/88(4)		2BA								18	
626	SS#33	YN	2/15/89(1)											
			12/13/89(4)									5BA		
LOWER HSU														
3487BR	CS	Y	03/09/88(1)											3J
			11/16/88(4)		2BA							3BA	5BA	
			08/23/89(3)											U
			12/13/89(4)									8A		
1687BR	SS#3	Y	02/29/88(1)									8		
			02/07/89(1)		2/A									U
			08/02/89(3)											
			11/06/89(4)											
			11/09/89(4)									5B		
2087BR	SS#3	Y	03/03/88(1)			13								70
			02/07/89(1)									5/A		3/A
			08/09/89(3)			19								140
			12/13/89(4)			22BA					11A			
			02/09/90(1)			6J					3J	2J		39
3486	SS#3	Y	03/02/88(1)											6

TABLE 2-6
SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Concluded)

Well Designation	Lithology of Screened Interval ^(a)	Analytical Data Availability ^(b)	Sample Date ^(c)	Volatile Organic Compounds Detected (µg/l)											
				Carbon Tetrachloride	Chloroform	Acetone	1,1-DCE	1,2-DCE	2-Hexanone	1,1,1-TCA	Methylene Chloride	Toluene	TCE	PCE	Carbon Disulfide
				LOWER HSU											
3087BR	CS	Y	03/02/88(1)									8		5	5

^{a)} SS#1 = Anapahoe Formation Sandstone #1; CS = Anapahoe Formation claystone/siltstone; AI = Alluvium; HSU = Hydrostratigraphic Unit

^{b)} Y = Yes as follows; YN = Yes but no data above detection limits

^{c)} Number in parentheses = calendar quarter sample was collected; D = duplicate sample

NOTES:

- (1) **VALUE QUALIFIERS:**
NR = Analyte not reported U = Analyzed but not detected * = Holding time not met E = Estimated value J = Present below detection limit B = Present in laboratory blank
N = Batch spike not in 80-120% range
- (2) **DATA VALIDATION QUALIFIERS:** (No validation qualifier indicates data has not been validated) R = Rejected; A = Acceptable with qualifications; V = Valid
- (3) Wells in upper HSU have portion of well screen or entire well screen in upper HSU.
- (4) Wells in lower HSU have entire well screen below boundary between "alluvial" and "bedrock" components of RFI/RI shown in Figure 1-1.
- (5) Well 1487BR is in lower HSU according to Note (4) above; however, it is screened in weathered SS#5 that subcrop and may be hydrologically connected to upper HSU.

weathered subcropping sandstone at relatively shallow depth (19 to 24 feet). This well may be hydrologically connected to the upper HSU.

Carbon Tetrachloride

Based on unvalidated data, carbon tetrachloride (CCl_4) was found as a dissolved constituent in groundwater from four wells in the upper HSU: 1587, 1287BR, 2587BR, and 3687BR (Table 2-6). The dissolved contaminant plume in the upper HSU was defined in the Phase II Alluvial Work Plan and is shown in Figure 2-21. The highest values found in the upper HSU were in 1587 (4305 $\mu\text{g/l}$) and 3687BR (3673 $\mu\text{g/l}$). Both are located to the east of the 903 Pad Area. Wells 2587BR and 3687BR are screened at deeper intervals in the upper HSU (18 to 44 feet and 19 to 63 feet, respectively) in the Arapahoe Formation Sandstone No. 1.

With the exception of Well 1487BR, which may be hydrologically connected to the upper HSU, CCl_4 was generally not found in lower-HSU wells. However, an estimated value of 1 ppb was recorded for bedrock Well 2387BR, located at the south-central portion of the Mound Area, in August 1989. This value is well below the method detection limit and is an isolated incident that when validated may receive additional qualifiers or may result in a different interpretation as to its significance.

Tetrachloroethylene (PCE)

The Phase I RI indicates the Mound Area appears to be a source of PCE contamination (Figure 2-22). A plume of PCE in the upper HSU with maximum concentrations greater than 100 $\mu\text{g/l}$ extends east and northeast from the Mound Area to Well 3687.

PCE was detected in Well 2387BR during the first (3 $\mu\text{g/l(J)}$) and third (1 $\mu\text{g/l(J)}$) quarters of 1989, although the concentrations were considerably lower than in wells toward the east end of the Mound Area. The detected values are below the method detection limit for PCE and should be considered suspect since the results are unvalidated. This well is screened in Arapahoe Formation Sandstone No. 1.

PCE (140 $\mu\text{g/l}$) was also noted in Well 2087BR, which is located at the east end of IHSS 113 and in well 1887BR (16 $\mu\text{g/l}$), located at the southeast corner of Mound Area. The screened depth interval for Well 2087BR is from 107 to 116 feet, which is in the Arapahoe Formation Sandstone No. 3, and the screened depth interval for Well 1887BR is from 127 to 134 feet, which is in the Arapahoe Formation Sandstone No. 4. This finding may suggest that some vertical migration has occurred, or that the well annulus is not well-sealed. Alternatively, it could indicate lateral migration of contamination from an upgradient source.

Trichloroethylene (TCE)

The distribution of TCE shown in the Alluvial Work Plan (Figure 2-23) indicates concentrations ranging up to 200,000 $\mu\text{g/l}$ (Table 2-6) in wells screened in the upper HSU. Significant concentrations of TCE were measured in upper-HSU Wells 1587, 1287BR, 2587BR, and 3687BR, with 3687BR having concentrations of 49000, 12000, and 18000 $\mu\text{g/l}$ over the first, third, and fourth quarter sampling events of 1989, respectively. In the lower HSU(s), isolated occurrences of TCE have been documented in 4086 BR and 3487BR, both screened at depths of approximately 100 feet in unweathered claystone (18 $\mu\text{g/l}$ and 3 $\mu\text{g/l}$ (J), 1 $\mu\text{g/l}$ (J), respectively). However, it should be noted that these values are near or below the method detection limit and the results are unvalidated. Validation of these results could result in qualification of the data as non-detects. As with CCl_4 , TCE has been detected in Well 1487BR, which may be hydrologically connected to the upper HSU.

Other Volatile Organic Compounds

Other volatile organic contaminants reported in groundwater samples from the deeper bedrock were toluene, chloroform, acetone, methylene chloride, and carbon disulfide. Toluene was found in Wells 4086, 3487BR, 1887BR and 4587BR. All values were low and were found in the blanks as well. The highest value 5 $\mu\text{g/l}$ (B,A) was from Well 1887BR (Table 2-6). Chloroform, acetone, and methylene chloride were present in many of the wells. All three of these compounds are common laboratory contaminants and many of the reported values were near or below the analytical detection limits and many of the laboratory blanks also contained these compounds. Carbon disulfide was detected only in Well 4587BR. Validation of these data may well result in qualification of most of these values as non-detects. Validation of existing data and additional sampling are needed to resolve whether or not these compounds are present in the bedrock. None of the other organic contaminants reported in the upper HSU were detected in the deeper bedrock.

2.2.3.2 Radionuclides

The radionuclide data were found not to have been validated and, therefore, should be used only to guide the placement of additional sampling locations. The interpretation of the radionuclide results was conducted in the same manner as they were in the Phase II Alluvial Work Plan. In general, data from the nine lower-HSU wells with data indicate radionuclides do not exceed reported background levels. In a few cases where background levels appear to be exceeded, the error terms associated with the reported values are near the reported values and it is therefore uncertain whether or not background levels were actually exceeded.

Results from Well 2387BR were the most elevated for plutonium-239,240 (0.07 ± 0.05 pCi/l), and from Well 2287BR for americium-241 (0.11 ± 0.08 pCi/l) (Table 2-7). These are bedrock wells; however, the top of the screen in Well 6286 is only 3 feet below the bedrock surface. Strontium-89 and -90 were detected in Wells 4587 BR (0.60 ± 0.52 pCi/l) and 6286 (3.0 ± 0.4 pCi/l). Radium was also detected in 4587 BR during the second quarter of 1989. Radium was not detected in previous or subsequent samples. Cesium-137 was reported in only six of the samples from lower-HSU wells, with the highest level being 0.3 ± 0.5 pCi/l (Well 6286). The values for plutonium-239 and -240 and cesium-137 have error terms greater than the analytical value and should be considered as not exceeding background. The error terms for the other radionuclides listed above are also nearly as large as the reported concentrations; therefore, the significance of those reported concentrations is also questionable.

Well 4587BR, located southwest of the 903 Pad Area, consistently had gross beta values above background (Table 2-7) with the highest being 113 ± 13 pCi/l. This well is screened at depths of 90-101 feet in the Arapahoe Formation Sandstone No. 5. Wells 1887BR and 2087BR, in the vicinity of the Mound Area, each had a single gross beta value above background.

Values above background were found in Well 1287BR for uranium-238. These values ranged from 18.9 ± 3.1 pCi/l to 28 ± 2 pCi/l. The screen interval for this well is at depths 5-11 feet in weathered claystone, with the top of the screen only 1.5 feet below the bedrock surface.

To summarize, the extent of radionuclides in the bedrock is not well defined. However, elevated gross beta values appear to occur Well 4587BR, which is screened in the Arapahoe Sandstone Formation No. 5.

2.2.3.3 Metals

The majority of the dissolved inorganic elements data (Tables 2-8A, B, and C) that had been validated were at or near the detection limits. Unvalidated data indicate metal concentrations exceeding background levels in the upper HSU in Operable Unit 2 include barium, copper, nickel, manganese and zinc.

Within Operable Unit 2, the wells with the highest concentrations of dissolved inorganic elements were in the 903 Pad Area. Silver, antimony, arsenic, barium, mercury, cadmium, selenium, beryllium, lead, and chromium were at their maximum values (see Table 2-8) in wells associated with the 903 Pad.

In general, elevated metal concentrations were not detected in bedrock wells. Well 6286BR, which is screened at depths 25 to 35 feet in the Arapahoe Formation Sandstone No. 3, had the highest values for mercury, cadmium, and selenium: 0.0008 mg/l, 0.009 mg/l, and 0.0710 mg/l, respectively. However, the top of the screen in this well is only 3 feet below the bedrock surface, and may therefore be hydraulically connected to the upper HSU. All values were unvalidated except for two selenium values, 0.0616 mg/l and 0.0565 mg/L, which have been validated (Table 2-8C).

TABLE 2-7

**SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs**

Well Designation	Lithology of Screened Interval ^(a)	Sample Date ^(a)	Gross Alpha pCi/l ^(b)	Gross Beta pCi/l	Uranium 233, 234 pCi/l	Uranium 235 pCi/l	Uranium 238 pCi/l	Strontium 89, 90 pCi/l	Plutonium 239, 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
UPPER HSU														
1587R	AL	09/11/87(3)	46±33	37±41	NR	NR	2.743±0.374	NR	0.522±0.117	0.831±0.148	NR	NR	NR	NR
		10/08/87(4)	NR	NR	NR	NR	1.364±0.216	NR	0.036±0.063	0.039±0.049	NR	NR	NR	NR
		10/08/87(D)	27±22	24±42	NR	0.06±0.01	0.73±0.18	NR	0.00±0.16	0.00±0.25	NR	NR	NR	NR
		03/01/88(1)	14±7	-5±17	NR	0.04±0.06	0.94±0.20	NR	0.00±0.19	0.00±0.10	NR	NR	NR	NR
		04/21/88(2)	-2±5 (12)	-8±14 (34)	NR	0.05±0.04(0.10)	0.84±0.27(0.94)	NR	0.00±0.05(0.13)	0.00±0.16(0.75)	NR	NR	NR	NR
		06/03/89(3)	0.7±0.6(0.9)	3.2±2.3(3.4)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		12/04/89(4)	3±3 (4)	5±3 (5)	NR	0.01±0.12(0.19)	0.9±0.2(0.10)	0.1±0.2(0.4)	0.007±0.004(0.004)	0.001±0.008(0.010)	-0.06±0.14(0.4)	NR	NR	NR
4086	CS	05/06/87(2)	33±13	41±21	10±2	0.39±0.52	6.1±1.5	0.66	0.24±0.73	1.0±4.6	NR	NR	NR	NR
		10/27/87(4)	106±18	207±15	NR	0.19±0.09	3.6±0.5	<1.0	0.00±0.14(0.84)	0.00±1.6(4.4)	NR	NR	NR	NR
		03/11/88(1)	46±16	23±16	NR	0.45±0.39	3.9±1.3	NR	0.00±0.11	0.00±0.33	NR	NR	NR	NR
		05/12/88(2)	17±6	2±14(33)	NR	0.12±0.04(0.20)	2.3±0.3	NR	0.00±0.03(0.18)	0.00±0.09(0.39)	NR	NR	NR	NR
6286	SS/S	04/09/87(2)	36±27	3±9	0.9±1.6	0.11±0.65	1.8±1.6	<0.6	0.0±1.1	0.0±1.3	NR	NR	NR	NR
		04/29/87(2)	30±12	8±37	4.9±1.3	0.75±0.54	3.6±1.1	0.44	0.0±1.3	0.0±1.4	NR	NR	NR	NR
		05/26/87(2)	14±3	35±13	3.4±1.2	0.10±0.35	2.8±1.0	<1.0	0.04±0.76	0.0±1.2	NR	NR	NR	NR
		07/07/87(3)	22±22	44±45	NR	0.50±0.40	3.2±1.0	<1.0	0.06±0.71	NR	NR	NR	NR	NR
		10/16/87(4)	13±5	11±10(19)	NR	0.15±0.07(0.17)	3.0±0.4	<1.0	0.04±0.09(0.44)	0.0±0.03(1.0)	NR	NR	NR	NR
		02/18/88(1)	14±5	1±12	NR	0.00±0.05	0.47±0.17	NR	0.0±0.18	0.0±0.13	NR	NR	NR	NR
		04/14/88(2)	13±8(13)	24±18(39)	NR	0.10±0.06(0.23)	3.2±0.6	NR	0.05±0.06(0.48)	0.0±0.16(0.48)	NR	NR	NR	NR
		07/15/88(3)	5±1	6±1	NR	0.10±0.04	3.3±0.4	NR	0.0±0.11	0.0±0.17	NR	NR	NR	NR

TABLE 2-7

**SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUS
(Continued)**

Well Designation	Lithology of Screened Interval ^(a)	Sample Date ^(b)	Gross Alpha pCi/l ^(c)	Gross Beta pCi/l	Uranium 233, 234 pCi/l	Uranium 235 pCi/l	Uranium 238 pCi/l	Strontium 89, 90 pCi/l	Plutonium 239, 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
1257BR	CS	10/20/88(4)	6±1	7±2	NR	0.07±0.04	NR	3.0±0.4	0.01±0.03	-0.01±0.08	NR	210	NR	NR
		01/24/89(1)	6±2	7±2	NR	NR	NR	NR	NR	NR	NR	<220	NR	NR
		04/20/89(2)	5.3±1.7(1.0)	9.2±3.8(5.0)	NR	NR	NR	NR	NR	NR	NR	<270	NR	NR
		06/10/89(3)	27±14	14±8	12.0±1.0	0.3±0.1	9.5±0.8	0.3±0.4	0.00±0.01	0.00±0.01	0.3±0.5	80±210	NR	NR
		07/20/89(3)	5±0.9(0.8)	9.2±2.7(3.5)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		10/19/89(4)	4.4±1.0(0.6)	5±1.8(2.4)	NR	0.07±1.3	0.26±0.27	0.63±0.44(0.63)	NR	NR	-0.1±0.39(0.66)	120±240(390)	NR	NR
		09/02/87(3)	121±48	47±45	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		02/26/88(1)	47±12	46±16	NR	1.7±0.3	28±2	NR	NR	0.0±0.09	NR	<220	NR	NR
		04/21/88(2)	52±14	57±20	NR	0.97±0.13	25±2	NR	0.0±0.04(0.17)	0.01±0.20(0.75)	NR	<210	NR	NR
		07/26/88(3)	37±4	22±3	NR	0.80±0.13	21±2	NR	0.0±0.08(0.23)	0.05±0.17(1.20)	NR	<210	NR	NR
		11/14/89(4)	30±3.2(2)	25.3±3(2)	NR	1.11±0.82(0)	18.9±3.1(0)	0.82±0.48(0)	0.004±0.004(0)	NR	0.06±0.40(0)	0±250(42)	NR	NR

TABLE 2-7

**SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Continued)**

Well Designation	Lithology of Screened Interval ^(a)	Sample Date ^(b)	Gross Alpha pCi/l ^(c)	Gross Beta pCi/l	Uranium 233, 234 pCi/l	Uranium 235 pCi/l	Uranium 238 pCi/l	Strontium 89, 90 pCi/l	Plutonium 239, 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
UPPER HSU														
2387BR	SS#1	09/11/87(3)	4±23	14±38	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		09/11/87D	NR	NR	NR	NR	4.299±0.563	NR	0.002±0.052	0.001±0.036	NR	NR	<400	NR
		10/22/87(4)	39±27	30±45	NR	NR	NR	NR	NR	NR	NR	NR	<520	NR
		03/03/88(1)	6±4 (6)	11±12 (26)	NR	0.14±0.07 (0.17)	2.2±0.3	NR	0.00±0.19 (0.34)	0.00±0.17 (1.1)	NR	NR	<210	NR
		04/29/88(2)	14±5	5±11 (24)	NR	0.13±0.04 (0.16)	1.9±0.3	NR	0.00±0.03 (0.22)	0.00±0.10 (0.65)	NR	NR	<200	NR
		08/12/88(3)	5±1	5±2	NR	0.08±0.05	1.9±0.3	NR	0.07±0.05	0.00±0.08	NR	NR	210	NR
		11/04/88(4)	4±2	4±2	NR	0.10±0.05	2.0±0.3	NR	-0.01±0.3	-0.04±0.08	NR	NR	230	NR
		02/08/89(1)	6±2	4±2	NR	0.09±0.04	2.1±0.2	NR	0.00±0.03 (0.09)	-0.07±0.08 (0.30)	NR	NR	<250	NR
		05/04/89(2)	4.5±0.7 (0.6)	5.9±2.7 (4.0)	NR	NR	NR	NR	NR	NR	NR	NR	<260	NR

TABLE 2-7

**SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs**
(Continued)

Well Designation	Lithology of Screened Interval ^(a)	Sample Date ^(b)	Gross Alpha pCi/l ^(c)	Gross Beta pCi/l	Uranium 233, 234 pCi/l	Uranium 235 pCi/l	Uranium 238 pCi/l	Strontium 89, 90 pCi/l	Plutonium 239, 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
UPPER HSU														
2587BR	SS#1	08/08/89(3)	2.5±0.3(0.3)	-1.3±2.2(3.8)	NR	0.05±0.19(0.25)	2.18±0.69(0)	NR	0.025±0.011(0.008)	0.003±0.007(0)	NR	NR	NR	NR
		08/08/89(4)	4.6±0.9(0.8)	6.9±2.7(3.7)	NR	0.33±0.49(0.51)	2.64±1.12(0.51)	NR	0.00±0.003(0)	NR	NR	NR	NR	NR
		12/04/89(4)	7±4(3)	10±4(6)	NR	0.0±0.07(0.03)	0.06±0.06(0.05)	-0.1±0.2(0.4)	0.0±0.002(0.005)	0.0±0.004(0.004)	-0.08±0.12(0.4)	NR	NR	NR
		02/20/90(1)	3±3(3)	4±1(2)	NR	0.3±0.2(0.07)	1.5±0.4(0.2)	0.1±0.3(0.5)	0.000±0.001(0.003)	-0.001±0.003(0.005)	0.1±0.2(0.6)	NR	NR	NR
		02/20/90(D)	3±2(3)	2±1(2)	NR	0.1±0.1(0.1)	1.3±0.4(0.1)	0.3±0.2(0.4)	0.002±0.004(0.005)	0.003±0.007(0.009)	0.0±0.2(0.5)	NR	NR	NR
		09/11/87(3)	14±25	30±36	NR	NR	NR	NR	NR	NR	NR	<460	NR	NR
		09/11/87(D)	NR ^(d)	NR	NR	NR	2.845±0.401	NR	NR	0.065±0.040	NR	NR	NR	NR
		10/22/87(4)	4±16	-12±37	NR	NR	NR	NR	NR	NR	NR	<520	NR	NR
		03/04/88(1)	7±5(8)	-2±11(26)	NR	0.06±0.08(0.40)	1.8±0.32	NR	0.00±0.19(0.78)	0.00±0.46(1.3)	NR	<210	NR	NR
		05/12/88(2)	19±7	8±14(33)	NR	0.04±0.04(0.10)	0.77±0.26(0.81)	NR	0.01±0.04(0.29)	0.00±0.09(0.41)	NR	<200	NR	NR
		08/16/88(3)	3±1	3±1	NR	0.01±0.04	0.82±0.20	NR	0.01±0.04	0.07±0.08	NR	210	NR	NR
		08/16/88(D)	3±1	2±1	NR	0.01±0.03	0.97±0.22	NR	0.00±0.04	0.00±0.08	NR	210	NR	NR
3687BR	SS#1/CS	02/16/89(1)	2±3(4)	1±2(4)	NR	0.09±0.04	0.92±0.15	NR	0.01±0.03(0.07)	-0.06±0.08(0.56)	NR	<260	NR	NR
		05/09/89(2)	1.8±1.1(1.5)	7.4±2.5(3.3)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		08/18/89(3)	1.7±0.8(1.0)	1.5±2.3(3.7)	NR	0.05±0.10(0)	0.93±0.43(0)	NR	0.006±0.005(0)	0.014±0.020(0.028)	NR	NR	NR	NR
		11/06/87(4)	2±20	-6±39	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		03/10/88(1)	17±7	23±14	NR	0.10±0.08	0.98±0.22	NR	0.00±0.12	0.00±0.15	NR	210±92	NR	NR
		05/05/88(2)	10±4	21±11(24)	NR	0.00±0.03(0.15)	0.63±0.25(1.2)	NR	0.00±0.05(0.10)	NR	NR	<220	NR	NR
		08/19/88(3)	2±1	2±1	NR	0.02±0.04	0.92±0.22	NR	0.03±0.04	0.04±0.08	NR	310±90	NR	NR
		02/16/89(1)	4±3	2±2(4)	NR	0.03±0.02(0.03)	1.4±0.2	NR	0.02±0.03(0.07)	0.00±0.05(0.10)	NR	<260	NR	NR

TABLE 2-7

**SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Continued)**

Lithology of Well Designation	Sample Date ^(a)	Gross Alpha pCi/l ^(b)	Gross Beta pCi/l ^(b)	Uranium 233, 234 pCi/l	Uranium 235 pCi/l	Uranium 238 pCi/l	Strontium 89, 90 pCi/l	Plutonium 239, 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
UPPER HSU													
3486	05/09/89(2)	3.9±1.5(1.8)	6.1±2.6(3.7)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	08/22/89(3)	1.5±0.5(0.5)	3.1±2.5(3.7)	NR	0.16±0.22(0)	1.32±0.71(0.51)	NR	0.013±0.004(0.002)	NR	NR	NR	NR	NR
	03/05/90(1)	7±3(2)	1±1(2)	NR	0.2±0.2(0.1)	1.6±0.5(0.2)	0.3±0.2(0.5)	0.001±0.008(0.011)	0.015±0.014(0.017)	0.08±0.08(0.5)	NR	NR	NR
LOWER HSU													
3486	03/17/87(1)	46±13	18±10	0.0±0.45	0.0±0.38	0.5±1.1	<0.6	0.00±0.92	0.0±2.2	NR	<110	NR	NR
	04/06/87(2)	27±19	26±23	1.7±2.2	0.0±1.2	0.0±2.2	NR	0.0±1.5	NR	NR	<110	NR	NR
	06/02/87(2)	66	18±20	0.39±0.85	0.0±0.34	0.04±0.53	1.4	0.98±0.99	0.0±1.8	NR	<110	NR	NR
	07/28/87(3)	0.0±59(11)	9±62(11)	NR	0.2±0.4	0.4±0.7	<1.0	-0.6±0.72	-0.4±5.5	NR	<478	NR	NR
	10/17/87(4)	3±10(18)	6±11(20)	NR	0.18±0.11(0.22)	1.2±0.3	1.2	0.00±0.72(1.3)	0.00±0.09(0.26)	NR	<460	NR	NR
	03/02/88(1)	6±13(28)	4±21(49)	NR	0.0±0.04(0.28)	0.13±0.13(0.43)	NR	0.00±0.40(3.6)	0.00±0.47(3.0)	NR	<210	NR	NR
	05/03/88(2)	8±9(17)	5±24(55)	NR	0.01±0.03(0.24)	0.19±0.23(2.0)	NR	0.00±0.04(0.13)	0.02±0.10(0.33)	NR	<210	NR	NR
	08/12/88(3)	3±3	7±5	NR	0.00±0.03	0.10±0.16	NR	0.00±0.04	0.00±0.09	NR	210	NR	NR
	11/04/88(4)	2±3(6)	9±6(14)	NR	0.00±0.02(0.06)	0.06±0.07(0.25)	NR	0.00±0.03(0.05)	-0.11±0.06(0.29)	NR	<220	NR	NR
	02/10/89(1)	5±4(11)	13±10(20)	NR	-0.01±0.02(0.05)	-0.11±0.08(0.20)	NR	-0.03±0.10(0.16)	-0.01±0.06(0.41)	NR	<260	NR	NR
1487BR	05/04/89(2)	7.0±2.6(2.7)	10.2±3.1(4.0)	NR	NR	NR	NR	NR	NR	NR	<270	NR	NR
	09/01/87(3)	17±21	23±41	NR	NR	NR	NR	NR	NR	NR	<500	NR	NR
	10/13/87(4)	6±17	16±40	NR	0.00±0.05	0.00±0.06	NR	0.00±0.15	0.00±0.22	NR	<460	NR	NR
	03/01/88(2)	10±7	19±13	NR	0.00±0.04	0.12±0.09	NR	0.00±0.19	0.00±0.11	NR	<210	NR	NR
	04/22/88(2)	8±4	18±11	NR	0.01±0.03	0.37±0.25	NR	0.00±0.03	0.00±0.16	NR	<200	NR	NR
	08/09/88(3)	1±1	7±2	NR	0.01±0.04	0.86±0.21	NR	0.00±0.04	0.03±0.09	NR	<210	NR	NR

TABLE 2-7

**SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Continued)**

Well Designation	Libology of Screened Interval ^(a)	Sample Date ^(b)	Gross Alpha pCi/l ^(c)	Gross Beta pCi/l ^(c)	Uranium 233, 234 pCi/l ^(c)	Uranium 235 pCi/l ^(c)	Uranium 238 pCi/l ^(c)	Strontium 89, 90 pCi/l ^(c)	Plutonium 239, 240 pCi/l ^(c)	Americium 241 pCi/l ^(c)	Cesium 137 pCi/l ^(c)	Tritium pCi/l ^(c)	Radium 226 pCi/l ^(c)	Radium 228 pCi/l ^(c)
LOWER HSU														
1887BR	SS#3	01/26/89(1)	1±1	5±2	NR	0.05±0.03	1.3±0.2	NR	-0.02±0.02	-0.01±0.03	NR	<230	NR	NR
		01/26/89(D)	NR	NR	NR	NR	NR	NR	0.00±0.03	0.01±0.06	NR	<230	NR	NR
		04/25/89(2)	1.0±0.6	3.6±2.5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		06/03/89(3)	3.1±0.9	3.7±2.3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		11/28/89(4)	7±4	9±2	NR	0±0.05	0.23±0.11	0±0.16	0±0.003	-0.01±0.03	0.01±0.18	NR	0.28±0.12	NR
		11/28/89(D)	5±4	12±3	NR	0±0.09	0.4±0.2	0.1±0.16	0.003±0.005	0.004±0.005	-0.03±0.15	NR	0.17±0.15	NR
		09/14/87(3)	14±24	23±40	NR	NR	NR	NR	NR	NR	NR	<500	NR	NR
		10/17/87(4)	48±27	17±39	NR	0.21±0.08	2.2±0.34	NR	0.05±0.09	0.01±0.07	NR	<460	NR	NR
		03/01/88(1)	10±4	12±18	NR	0.14±0.07	1.8±0.2	NR	0.00±0.14	0.03±0.12	NR	<220	NR	NR
		04/22/88(2)	12±4	16±10	NR	0.04±0.03 (0.09)	1.7±0.2	NR	0.02±0.04 (0.14)	0.02±0.16 (0.51)	NR	<210	NR	NR
		06/10/88(3)	2±1 (3)	0±2 (4)	NR	NR	NR	NR	0.00±0.04 (0.12)	0.02±0.09 (0.36)	NR	<210	NR	NR
		02/08/89(1)	2±1 (3)	6±2	NR	0.03±0.02 (0.06)	1.2±0.2	NR	-0.06±0.09 (0.17)	0.03±0.06 (0.46)	NR	<220	NR	NR
		05/02/89(2)	4.4±1.0 (0.7)	8.3±2.6 (3.5)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		06/03/89(3)	4.4±1.2 (1.1)	4.6±2.5 (3.7)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		11/06/89(4)	6±2 (2)	3.8±.9 (1)	NR	0.1±0.2 (0.07)	2.5±0.6 (0.05)	0±0.2 (0.5)	-0.001±0.005 (0.01)	-0.003±0.004 (0.007)	0.20±0.16 (0.7)	NR	NR	NR
		11/09/89(4)	6±2 (2)	3.8±.9 (1)	NR	0.1±0.2 (0.07)	2.5±0.6 (0.05)	0±0.2 (0.5)	-0.001±0.005 (0.01)	-0.003±0.004 (0.007)	0.20±0.16 (0.7)	NR	NR	NR
1887BR	SS#4	03/08/88(1)	7±9 (16)	24±15 (34)	NR	0.09±0.12 (0.9)	0.21±0.24 (1.2)	NR	0.02±0.09 (0.4)	0.00±0.24 (1.2)	NR	<220	NR	NR
2087BR	SS#3	03/04/88(1)	8±12 (27)	37±22 (47)	NR	NR	NR	NR	0.00±0.18 (0.68)	0.00±0.24 (1.1)	NR	<200	NR	NR
2287BR	SS#4	03/08/88(1)	22±9	12±16	NR	0.18±0.10	1.6±0.3	NR	0.00±0.16	0.00±0.04	NR	<210	NR	NR
		05/03/88(1)	6±6	5±16	NR	0.14±0.05	1.0±0.3	NR	0.00±0.04	0.00±0.10	NR	<210	NR	NR

TABLE 2-7

**SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Continued)**

Well Designation	Lithology of Screened Interval(s)	Sample Date ^(a)	Gross Alpha pCi/l ^(b)	Gross Beta pCi/l ^(b)	Uranium 233, 234 pCi/l ^(b)	Uranium 235 pCi/l ^(b)	Uranium 238 pCi/l ^(b)	Strontium 89, 90 pCi/l ^(b)	Plutonium 239, 240 pCi/l ^(b)	Americium 241 pCi/l ^(b)	Cesium 137 pCi/l ^(b)	Tritium pCi/l ^(b)	Radium 226 pCi/l ^(b)	Radium 228 pCi/l ^(b)
LOWER HSU														
2887BR	CS	08/12/88(3)	3±1	11±2	NR	0.02±0.04	1.2±0.2	NR	0.00±0.04	0.02±0.08	NR	210	NR	NR
		11/09/88(4)	3±2	12±2	NR	0.02±0.03	1.4±0.2	NR	-0.8±0.13	-0.6±0.5	NR	<220	NR	NR
		02/10/89(1)	5±3	11±2	NR	0.03±0.03	1.4±0.2	NR	-0.05±0.10	0.11±0.08	NR	<250	NR	NR
		05/04/89(2)	7.5±1.3	12.5±3.1	NR	NR	NR	NR	NR	NR	NR	<270	NR	NR
		08/16/89(3)	6.4±1.5	12.5±4.2	NR	0.07±0.14	1.25±0.59	NR	0.005±0.004	0.031±0.026	NR	NR	NR	NR
		11/10/89(4)	3±4	3±3	NR	0.11±0.15	1.1±0.4	-0.01±0.14	0.002±0.005	-0.001±0.003	0±0.3	NR	NR	NR
		11/13/89(4)	3±4	3±3	NR	0.11±0.15	1.1±0.4	-0.01±0.14	0.002±0.005	-0.001±0.003	0±0.3	NR	NR	NR
		03/15/88(1)	6±5	14±12	NR	0.01±0.05	0.25±0.11	NR	0.0±0.23	0.0±0.29	NR	210	NR	NR
		05/12/88(2)	4±4 (8)	-10±15 (86)	NR	0.07±0.04(0.14)	1.6±0.3	NR	0.0±0.03(0.14)	0.1±0.07(0.65)	NR	<220	NR	NR
		02/21/89(1)	7±2	6±2	NR	0.07±0.03	1.8±0.2	NR	-0.02±0.03(0.07)	0.05±0.05(0.15)	NR	<260	NR	NR
3087BR	CS	12/06/89(4)	14.8±4.2(3.0)	9.5±5.4(7.0)	NR	0.11±0.37(8)	1.58±0.92(6)	NR	NR	NR	NR	NR	NR	NR
		01/22/88(1)	1±5	3±12	NR	0.01±0.04	0.11±0.09	<1.0	0.00±0.15	0.17±0.12	NR	<200	NR	NR
		03/03/88(1)	33±11	4±27	NR	NR	NR	NR	0.00±0.25	0.05±0.13	NR	<220	NR	NR
		04/22/88(2)	3±5	1±10	NR	0.00±0.03	0.53±0.26	NR	0.00±0.04	0.01±0.16	NR	<210	NR	NR
		08/09/88(3)	2±1	-2±1	NR	0.00±0.03	0.24±0.17	NR	0.00±0.04	0.00±0.09	NR	<210	NR	NR
		08/09/88(3)	-1±1	-1±1	NR	0.00±0.03	0.37±0.18	NR	0.00±0.04	0.00±0.09	NR	<210	NR	NR
		02/02/89(1)	0±1	3±2	NR	0.00±0.02	0.09±0.07	NR	0.01±0.10	0.06±0.08	NR	<220	NR	NR
		04/25/89(2)	1.5±0.4	2.8±2.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		08/03/89(3)	0.0±1.3	4.6±2.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		08/03/89(3)	0.0±1.3	4.6±2.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

TABLE 2-7

**SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Continued)**

Well Designation	Lithology of Screened Interval ^(a)	Sample Date ^(a)	Gross Alpha pCi/l ^(e)	Gross Beta pCi/l	Uranium 235, 234 pCi/l	Uranium 235 pCi/l	Uranium 238 pCi/l	Strontium 89, 90 pCi/l	Plutonium 239, 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
LOWER HSU														
3187BR	SS#3	12/08/89(4)	1.8±1.4	1.6±0.8	NR	0±0.10	0.3±0.2	0±0.2	0.009±0.006	-0.001±0.004	0.33±0.10	NR	NR	NR
		12/12/89(4)	1.8±1.4	1.6±0.8	NR	0±0.10	0.3±0.2	0±0.2	0.009±0.006	-0.001±0.004	0.33±0.10	NR	NR	NR
		10/29/87(4)	36±34	26±43	NR	NR	NR	NR	NR	NR	NR	<400	NR	NR
		05/10/88(1)	14±8	15±16	NR	NR	NR	NR	0.00±0.11	0.0±0.17	NR	NR	NR	NR
		05/12/88(2)	12±6	2±14	NR	0.08±0.04	0.24±0.23	NR	0.00±0.04	0.03±0.09	NR	<200	NR	NR
		06/25/88(3)	1±1	4±1	NR	0.00±0.03	0.45±0.18	NR	0.00±0.04	0.06±0.08	NR	200	NR	NR
		02/23/89(1)	2±1	4±2	NR	0.03±0.03	0.44±0.09	NR	0.00±0.03	-0.04±0.08	NR	<200	NR	NR
		05/11/89(2)	1.9±1.0	5.4±2.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
3487BR	CS	12/14/89(4)	3.6±1.8	1.7±0.8	NR	0.07±0.14	0.08±0.5	0±0.5	0.005±0.004	0.002±0.007	0±0.08	NR	NR	NR
		03/10/88(1)	4±10	16±16	NR	0.21±0.12	0.30±0.23	NR	0.0±0.15	0.0±0.24	NR	200	NR	NR
		05/12/88(2)	6±4 (7)	4±8 (18)	NR	0.04±0.03 (0.25)	1.3±0.3 (2.1)	NR	0.0±0.03 (0.14)	0.00±0.09 (0.53)	NR	<210	NR	NR
		05/12/88(3)	1±5 (12)	7±8 (19)	NR	0.07±0.04 (0.09)	1.0±0.3	NR	0.0±0.03 (0.16)	0.03±0.12 (0.72)	NR	<210	NR	NR
		02/21/89(2)	4±2	3±3 (8)	NR	0.04±0.02	1.0±0.1	NR	-0.02±0.03 (0.06)	0.01±0.05 (0.07)	NR	<200	NR	NR
		06/24/89(3)	4.2±0.9 (0.8)	5±2.4 (3.5)	NR	0.11±0.23 (0.26)	0.73±0.44 (0.26)	NR	NR	NR	NR	NR	NR	NR
		11/24/87(4)	32±9	113±13	NR	0.08±0.05 (0.10)	1.4±0.2	<1.0	0.00±0.12 (0.56)	0.00±1.4 (6.9)	NR	<220	NR	NR
		02/26/88(1)	9±5	29±11	NR	0.12±0.10	1.2±0.3	NR	0.00±0.18	NR	NR	<200	NR	NR
4587BR	SS#5	04/19/88(2)	7±8 (14)	21±15 (32)	NR	0.03±0.03 (0.10)	1.1±0.2	NR	0.00±0.03 (0.15)	0.10±0.16 (0.81)	NR	<200	NR	NR
		07/22/88(3)	2±1	14±2	NR	0.02±0.04	0.79±0.20	NR	0.00±0.04	0.00±0.12	NR	210	NR	NR
		01/24/89(1)	2±1	11±2	NR	NR	NR	NR	NR	NR	NR	<220	NR	NR
		04/20/89(1)	3.5±1.3 (1.5)	11.1±3.0 (3.8)	NR	NR	NR	NR	NR	NR	NR	<270	NR	NR

TABLE 2-7

**SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Concluded)**

Well Designation	Lithology of Screened Interval ^(a)	Sample Date ^(a)	Gross Alpha pCi/g ^(c)	Gross Beta pCi/g	Uranium 233, 234 pCi/g	Uranium 235 pCi/g	Uranium 238 pCi/g	Strontium 89, 90 pCi/g	Plutonium 239, 240 pCi/g	Americium 241 pCi/g	Cesium 137 pCi/g	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
LOWER HSU														
06/13/89(2)		5 ± 5 (7)	10 ± 3 (4)	NR	0.0 ± 0.1 (0.1)	0.2 ± 0.1 (0.1)	0.2 ± 0.6 (1.0)	0.00 ± 0.01 (0.01)	0.1 ± 0.6 (1.1)	0.00 ± 0.01 (0.01)	0.1 ± 0.6 (1.1)	90 ± 210 (250)	0.4 ± 0.4 (0.4)	NR
07/27/89(3)		2.0 ± 0.5 (0.6)	8.9 ± 2.7 (3.6)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
08/17/89(3)		1 ± 4 (6)	8 ± 3 (4)	NR	0.0 ± 0.1	0.2 ± 0.2	0.3 ± 0.5	0.00 ± 0.01	0.0 ± 0.5	0.00 ± 0.01	0.0 ± 0.5	140 ± 200 (27)	NR	NR
10/20/89(4)		3.0 ± 1.4 (1.7)	7.2 ± 2.2 (3.0)	NR	0.04 ± 0.14 (0.18)	0.73 ± 0.43	0.60 ± 0.52 (0.77)	NR	NR	NR	0.16 ± 0.68 (1.1)	-120 ± 220 (370)	NR	NR
10/20/89(D)		2.8 ± 1.1 (1.2)	9.7 ± 2.2 (2.7)	NR	0.04 ± 0.08	0.40 ± 0.29 (0.96)	-0.09 ± 0.75 (1.24)	NR	NR	NR	0.14 ± 0.45 (0.72)	-200 ± 210 (360)	NR	NR

^(a) SS#1 = Arecibo Formation Sandstone #1; CS = Arecibo Formation Claystone/Siltstone; AI = Alluvium

^(b) Number in parenthesis = the calendar quarter sample was collected. D = Duplicate.

^(c) Values in parenthesis are detection limits.

^(d) NR = value not reported

^(e) Wells screened in interval representing lower hydrostratigraphic unit(s) (i.e., top of screen below boundary between "alluvial" and "bedrock" components of RE/RI shown in Figure 1-1).

NOTES:

(1) VALUE QUALIFIERS:

NR = Analyte not reported; LL = Analyzed but not detected; * = Holding time not met; E = Estimated value; J = Present below detection limit; B = Present in laboratory blank; N = Batch spike not in 90-120% range

(2) DATA VALIDATION QUALIFIERS: (No validation qualifier indicates data has not been validated) R = Rejected; A = Acceptable with qualifications; V = Valid

(3) Wells in upper HSU have portion of well screen or entire well screen in upper HSU.

(4) Wells in lower HSU have entire well screen below boundary between "alluvial" and "bedrock" components of RE/RI shown in Figure 1-1.

(5) Well 1487BR is in lower HSU according to Note (4) above; however, it is screened in weathered SS #5 that subcrops and may be hydrologically connected to upper HSU.

TABLE 2-8A

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Aluminum-Chromium)**

Well Designation	Lithology of Screened Interval ^{1a}	Sample Date ^{1b}	Aluminum (Al), diss. mg/l	Antimony (Sb), diss. mg/l	Arsenic (As), diss. mg/l	Barium (Ba), diss. mg/l	Beryllium (Be), diss. mg/l	Cadmium (Cd), diss. mg/l	Calcium (Ca), diss. mg/l	Cesium (Cs), diss. mg/l	Chromium (Cr), diss. mg/l
UPPER HSU											
1587	AL	10/08/87(D)	0.0290 U	NR	NR	0.1920	NR	NR	134.0580	NR	0.0100 U
		10/08/87(4)	0.0358	0.020 U	0.005 U	0.1917	0.005 U	0.001 U	133.3401	0.020 U	0.0100 U
		03/01/88(1)	0.0449	0.019	0.005 U	0.1807	0.003 J	0.001 U	117.2322	0.020 U	0.0380
		04/21/88(2)	0.0499	0.034 U	0.005 U	0.1561	0.001 U	0.005 U	125.8376	0.020 U	0.0100 U
		08/03/89(3)	0.0316 J	0.050 U	NR	0.1358 J	0.002 U	0.005 U	92.7538	NR	0.0090 U
		12/04/89(4)	0.200 U	0.060 U	0.010 U	0.2000 U	0.005 U	0.005 U	113.0000	2.500 U	0.0100 U
6286	SS #3	04/09/87(2)	0.1455	0.060 U	0.010 U	0.0229	0.005 U	0.005 U	37.1320	0.02 U	0.1280
		04/29/87(2)	0.0839	0.060 U	0.010 U	0.0191	0.005 U	0.005 U	32.5061	0.02 U	0.0100 U
		07/07/87(3)	0.0600	0.020 U	0.005 U	0.0356	0.005 U	0.0003 J	35.4258	0.02 U	0.0189
		10/16/87(4)	0.0479	0.020 U	0.005 U	0.0375	0.005 U	0.001 U	27.7660	0.02 U	0.0453
		02/18/88(1)	0.0300	0.020 U	0.003 J	0.0412	0.005 U	0.001 U	28.6004	0.02 U	0.0216
		04/14/88(2)	0.0381	0.034 U	0.005 U	0.0358	0.001 U	0.005 U	32.9081	0.02 U	0.0193
		07/15/88(3)	0.0341	0.034 U	0.005 U	0.0404	0.001 U	0.005 U	32.9175	0.02 U	0.229
		10/20/88(4)	0.0626	0.034 U	0.005 U	0.0499	0.001 U	0.005 U	37.0527	0.02 U	0.0231
		01/23/89(1)	0.0095 V	0.050 U V	0.001 U V	0.0415 V	0.002 U V	0.005 U R	33.2000 V	0.005 U V	0.0290 V
		06/10/89(2)	0.200 U V	0.600 U A	0.010 U V	0.2000 U R	0.005 U A	0.009 A	34.5000 A	1.00 U V	0.0246 A
		07/20/89(3)	0.0333 J	0.050 U	NR	0.0453 J	0.002 U	0.005 U	33.7356	NR	0.0189
		10/19/90(4)	0.0304	0.5000 U	0.0072	0.0500 U	0.002 U	0.004 U	32.1000	0.001 U	0.0215
1287BR	CS	02/26/88(1)	0.0290 U	0.02 U	0.005 U	0.0434	0.005 U	0.001 U	31.0631	0.020 U	0.0100 U
		04/21/88(2)	0.0470	0.034 U	0.005 U	0.0332	0.001 U	0.005 U	36.1776	0.020 U	0.0100 U
		07/26/88(3)	0.0351	0.034 U	0.005 U	0.0508	0.001 U	0.005 U	38.1220	0.020 U	0.0561

TABLE 2-8A

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Aluminum-Chromium)
(Continued)**

Well Designation	Lithology of Screened Interval ^a	Sample Date ^b	Aluminum (Al), diss. mg/l	Antimony (Sb), diss. mg/l	Arsenic (As), diss. mg/l	Barium (Ba), diss. mg/l	Beryllium (Be), diss. mg/l	Cadmium (Cd), diss. mg/l	Calcium (Ca), diss. mg/l	Cesium (Cs), diss. mg/l	Chromium (Cr), diss. mg/l
UPPER HSU											
2387BR	SS #1	10/22/87(4)	0.1725	NR	NR	0.1632	NR	NR	94.3186	NR	0.0676
		03/03/88(1)	0.0969	0.028 U	0.005 U	0.1949	0.005 U	0.001 U	130.1240	0.020 U	0.0100 U
		04/29/88(2)	0.0290 U	0.034 U	0.005 U	0.1625	0.001 U	0.005 U	115.0052	0.020 U	0.0100 U
		11/04/88(4)	0.0290 U	0.034 U	0.005 U	0.1693	0.001 U	0.005 U	120.6239	0.020 U	0.0100 U
		02/07/89(1)	0.1920 J	0.050 U	0.001 U	0.1731 J	0.002 U	0.005 U	118.1832	0.005 U	0.0090 U
		12/04/89(4)	0.2000 U	0.060 U	0.010 U	0.2000 U	0.005 U	0.005 U	115.0000	2.500 U	0.0100 U
		10/22/87(4)	2.6796	NR	NR	0.1524	NR	NR	110.7037	NR	0.0785
2587BR	SS #1	03/04/88(1)	0.0290 U	0.020 U	0.005 U	0.1128	0.005 U	0.001 U	116.7854	0.020 U	0.0100 U
		05/12/88(2)	0.0968	0.034 U	0.005 U	0.0769	0.001 U	0.005 U	105.3446	0.020 U	0.0100 U
		08/16/88(3)	0.0897	0.034 U	0.005 U	0.0937	0.001 U	0.005 U	119.8486	0.020 U	0.0100 U
		02/15/89(1)	0.6140 J	0.050 U	0.001 U	0.1269 J	0.002 U	0.005 U	124.3472	0.005 U	0.0090 U
		11/02/89(4)	0.0300 U	0.500 U	0.002 U	0.1050	0.002 U	0.004 U	115.0000	0.001 U	0.0200 U
		11/06/87(4)	0.0327	NR	NR	0.1858	NR	NR	98.4384	NR	0.0100 U
		03/10/88(1)	0.0290 U	0.02 U	0.005 U	0.1700	0.005 U	0.001 U	110.3891	0.020 U	0.0100 U
3687BR	SS #1/CS	05/05/88(2)	0.0680	0.034 U	0.005 U	0.1176	0.001 U	0.005 U	104.1592	0.020 U	0.0220
		08/19/88(3)	0.0290 U	0.034 U	0.005 U	0.1435	0.001 U	0.005 U	112.5575	0.020 U	0.0154
		02/15/89(1)	0.0249 J	0.0500 U	0.0010 U	0.2179	0.0020 U	0.0050 U	123.4178	0.0050 U	0.0090 U
		11/10/89(4)	0.200 U V	0.060 U R	0.010 U V	0.200 U V	0.005 U V	0.005 U V	127.0000 A	2.500 U V	0.100 U A

TABLE 2-8A

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Aluminum-Chromium)
(Continued)**

Well Designation	Lithology of Screened Interval ^a	Sample Date ^b	Aluminum (Al), diss. mg/l	Antimony (Sb), diss. mg/l	Arsenic (As), diss. mg/l	Barium (Ba), diss. mg/l	Beryllium (Be), diss. mg/l	Cadmium (Cd), diss. mg/l	Calcium (Ca), diss. mg/l	Cesium (Cs), diss. mg/l	Chromium (Cr), diss. mg/l
LOWER HSU											
3486	SS#3	03/17/87(1)	0.0290 U	0.06 U	0.010 U	0.0288	0.005 U	0.005 U	241.5299	0.2 U	0.0100 U
		04/06/87(2)	0.0290 U	0.06 U	0.010 U	0.0878	0.005 U	0.005 U	236.2398	0.2 U	0.0100 U
		06/02/87(2)	0.0334	0.06 U	0.010 U	0.0247	0.005 U	0.005 U	235.2524	0.2 U	0.0114
		07/28/87(3)	0.0524	0.02 U	0.005 U	0.0354	0.005 U	0.001 U	242.3112	0.02 U	0.0100 U
		10/17/87(4)	0.0290	0.02 U	0.002 J	0.0308	0.005 U	0.001 U	209.5497	0.02 U	0.0120
		03/03/88(1)	0.1729	0.02 U	0.004 J	0.1216	0.005 U	0.001 U	18.6393	0.02 U	0.0100 U
		05/03/88(2)	0.029 U	0.034 U	0.005 U	0.0271	0.001 U	0.005 U	207.6940	0.02 U	0.0100 U
		11/04/88(4)	0.0379	0.0728	NR	0.0276	0.001 U	0.005 U	233.7848	0.02 U	0.0100 U
		02/09/89(1)	0.0193 J	0.05 U	0.024 UB	0.0219 J	0.002 U	0.005 U	228.7841	0.005 U	0.0167
		05/06/87(2)	0.4668	0.060 U	0.0100 U	0.0719	0.005 U	0.0050 U	152.5210	0.200 U	0.0100 U
4086	CS	10/27/87(4)	0.0561	0.020 U	0.0050 U	0.0729	0.005 U	0.0003 J	75.2480	0.020 U	0.0270
		03/11/88(1)	0.290 U	0.020 U	0.0050 U	0.0540	0.005 U	0.004	76.2347	0.020 U	0.0100 U
		05/12/88(2)	0.2900 U	0.0340 U	0.0050 U	0.0476	0.0010 U	0.0059 U	67.6288	0.2000 U	0.0100 U
		12/04/89(4)	0.0364	0.500 U	0.0020 U	0.0598	0.002 U	0.004 U	77.2000	1.00 U	0.0200 U
		10/13/87(4)	1.1972	0.029	0.005 U	0.1196	0.001 J	0.001 U	81.2350	0.02 U	0.0382
		03/01/88(1)	0.1598	0.02 U	0.005 U	0.0297	0.005 U	0.001 U	7.5573	0.02 U	0.0207
		04/23/88(1)	0.1141	0.0340 U	0.005 U	0.0269	0.0010 U	0.0050 U	6.0019	0.02 U	0.0252
		08/09/88(3)	0.1238	0.0340 U	0.005 U	0.0298	0.0010 U	0.0050 U	7.7025	0.02 U	0.0100 U
		01/25/89(1)	0.0683 J	0.050 U	0.001 U	0.0684 J	0.002 U	0.0050 U	27.1815	0.0050 U	0.0182
		01/25/89(1)	0.0572 J	0.050 U	0.001 U	0.0666 J	0.002 U	0.0050 U	26.2288	0.0050 U	0.0184

Phase II RTR/R Work Plan (Recheck) - 903 Prod. Monitor, and East Trenches Areas, Draft Final
Rocky Flats Plant, Golden, Colorado, January 24, 1991
21578E/RIT.28A 01-04-91/RFT/2

TABLE 2-8A

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Aluminum-Chromium)
(Continued)**

Well Designation	Lithology of Screened Interval ^a	Sample Date ^b	Aluminum (Al), diss. mg/l	Antimony (Sb), diss. mg/l	Arsenic (As), diss. mg/l	Barium (Ba), diss. mg/l	Beryllium (Be), diss. mg/l	Cadmium (Cd), diss. mg/l	Calcium (Ca), diss. mg/l	Cesium (Cs), diss. mg/l	Chromium (Cr), diss. mg/l
LOWER HSU											
1687BR	SS#3	08/03/89(3)	0.0605 J	0.0500 U	NR	0.0537 J	0.0020 U	0.0050 U	14.4856	NR	0.0109
		11/28/89(4)	0.200 U	0.0600 U	0.0100 U	0.200 U	0.0050 U	0.0050 U	53.40	1.00 U	0.0100 U
		10/17/87(4)	0.0876	NR	NR	0.0354	NR	NR	20.5145	NR	0.2780
		03/01/88(1)	0.0814	0.020 U	0.004 J	0.7860	0.005 U	0.001 U	18.4820	0.02 U	0.0100 U
		04/22/88(2)	0.4850	0.034 U	0.003 J	0.0456	0.001 U	0.005 U	24.7026	0.02 U	0.0100 U
		08/10/88(3)	0.0433	0.034 U	0.005 U	0.0280	0.001 U	0.005 U	26.4029	0.02 U	0.0114
		02/07/89(1)	0.0455 J	0.050 U	0.0028 J	0.0442 J	0.002 U	0.005 U	29.3102	0.005 U	0.0123
		08/03/89(3)	0.0260 J	0.050 U	NR	0.0285 J	0.200 U	0.005 U	30.3920	NR	0.0097 J
		11/09/89(3)	0.0200 U	0.0600 U	0.0100 U	0.2000 U	0.0050 U	0.0050 U	29.8000	2.5000 U	0.0100 U
		11/06/89(4)	0.2000 U	0.060 U	0.010 U	0.200 U	0.005 U	0.005 U	29.8000	2.50 U	0.0100 U
1887BR	SS#4	03/08/88(1)	0.0879	0.0200 U	0.0030 J	0.1084	0.0050 U	0.0010 U	12.3260	0.0200 U	0.0118
		03/08/88(1)	0.0406	0.02 U	0.004 J	0.0594	0.005 U	0.001 U	30.2374	0.020 U	0.0115
		05/03/88(2)	0.0376	0.034 U	0.005 U	0.0343	0.001 U	0.005 U	34.1294	0.020 U	0.0100
		11/09/88(4)	0.0476	0.034 U	0.003 J	0.0411	0.001 U	0.005 U	49.0811	NR	0.0100 U
		02/09/89(1)	0.01944	0.050 U	0.0045 J	0.0411 J	0.002 U	0.005 U	54.2755	0.005 U	0.0106
2287	CS	11/10/89(4)	0.200 U V	0.060 U R	0.0100 U V	0.200 U V	0.005 U V	0.005 U V	62.70	2.50 U V	0.010 U V
		11/13/89(4)	0.200 U V	0.060 U R	0.0100 U V	0.200 U V	0.005 U V	0.005 U V	62.70	2.50 U V	0.010 U V
		03/15/88(1)	0.0290 U	0.02 U	0.004 J	0.0238	0.005 U	0.001	13.1315	0.02 U	0.0100 U
		05/12/88(2)	0.2705	0.034 U	0.005 U	0.0913	0.001 U	0.005 U	19.9311	0.02 U	0.0100 U
		02/20/89(1)	0.0918 J	0.05 U	0.0022 J	0.042 J	0.002 U	0.005 U	35.1215	0.005 U	0.0151

Phase II RPT/R1 Work Plan (Redacted) - 905 Feet, Mound, and East Trench Area, Draft Final
Rocky Flats Plant, Golden, Colorado, January 24, 1991
21578/U/R17.28A 01-04-91/RPT/2

TABLE 2-8A

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Aluminum-Chromium)
(Continued)**

Well Designation	Lithology of Screened Interval ^(a)	Sample Date ^(b)	Aluminum (Al), diss. mg/l	Antimony (Sb), diss. mg/l	Arsenic (As), diss. mg/l	Barium (Ba), diss. mg/l	Beryllium (Be), diss. mg/l	Cadmium (Cd), diss. mg/l	Calcium (Ca), diss. mg/l	Cesium (Cs), diss. mg/l	Chromium (Cr), diss. mg/l
LOWER HSU											
3087BR	CS	01/22/88(1)	0.0833	0.0200 U	0.040	0.0308	0.005 U	0.001 U	17.5065	0.02 U	0.0100 U
		03/03/88(1)	0.0646	0.0200 U	0.013	0.0626	0.005 U	0.001 U	16.8116	0.02 U	0.0100 U
		04/22/88(2)	0.0328	0.0340 U	0.006	0.0534	0.0010 U	0.0050 U	18.9773	0.02 U	0.0100 U
		08/09/88(3)	0.0290 U	0.0340 U	0.005 U	0.0984	0.0010 U	0.0050 U	19.3281	0.02 U	0.0100 U
		02/01/89(1)	0.015 U	0.0500 U	0.0017 J	0.0847 J	0.0022 J	0.005 U	17.9101	0.005 U	0.009 U
		12/08/89(4)	0.0331	0.5000 U	0.0020 U	0.101	0.0020 U	0.0040 U	19.30	1.00 U	0.0200 U
		12/12/89(4)	0.0331	0.5000 U	0.0020 U	0.101	0.0020 U	0.0040 U	19.30	1.00 U	0.0200 U
		02/09/90(1)	0.200 U	0.0100 U	0.0100 U	0.200 U	0.0050 U	0.0050 U	21.00	1.00 U	0.0100 U
		10/29/87(4)	0.2634	NR	NR	0.0562	NR	NR	15.3345	NR	0.0260
		05/12/88(2)	0.2029	0.0340 U	0.008	0.0472	0.0010 U	0.0050 U	20.2619	0.02 U	0.0100 U
3487BR	CS	08/25/88(3)	0.0419	0.0340 U	0.0053	0.0408	0.0010 U	0.0050 U	22.0879	0.020 U	0.0100 U
		02/22/89(1)	0.0165 J	0.0500 U	0.0047 J	0.0179 J	0.002 U	0.0050 U	19.2669	0.005 U	0.009 U
		03/10/88(1)	0.0290 U	0.02 U	0.007	0.0424	0.005 U	0.001 U	192.5822	0.002 U	0.0123
		05/12/88(2)	0.1194	0.034 U	0.005 U	0.0486	0.001 U	0.005 U	19.3843	0.02 U	0.0111
		05/12/88(2)	0.1204	0.034 U	0.005 U	0.0463	0.001 U	0.005 U	17.8546	0.02 U	0.0109
4587BR	SS #5	02/20/89(1)	0.0442 J	0.050 U	0.0024 J	0.0441 J	0.002 U	0.005 U	15.7051	0.005 U	0.0090 U
		12/13/89(4)	0.200 U	0.060 U	0.0036	0.200 U	0.005 U	0.005 U	18.5000	1.00 U	0.0100 U
		11/24/87(4)	0.1306	0.020 U	0.004 J	0.1658	0.005 U	0.0058	19.7961	0.02 U	0.0100 U
		02/26/88(1)	0.0357	0.020 U	0.003 J	0.0829	0.005 U	0.001 U	26.9376	0.02 U	0.0100 U
		04/19/88(2)	0.0360	0.034 U	0.005 U	0.0569	0.001 U	0.005 U	29.3511	0.02 U	0.0109

Phase II R/F/R/L Work Plan (Redrock) - 903 Pad, Mount, and East Trenches Areas, Draft Final
Rocky Flats Plant, Golden, Colorado, January 24, 1991
21578/RIT.28A 01-04-91/RPT/2

TABLE 2-8A

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Aluminum-Chromium)
(Concluded)**

Well Designation	Lithology of Screened Interval ⁽¹⁾	Sample Date ⁽²⁾	Aluminum (Al), dis. mg/l	Antimony (Sb), dis. mg/l	Arsenic (As), dis. mg/l	Barium (Ba), dis. mg/l	Beryllium (Be), dis. mg/l	Cadmium (Cd), dis. mg/l	Calcium (Ca), dis. mg/l	Cesium (Cs), dis. mg/l	Chromium (Cr), dis. mg/l
LOWER HSU											
07/22/88(3)			0.0290 U	0.034 U	0.005 U	0.0380	0.001 U	0.005 U	34.3743	0.02 U	0.0100 U
01/23/89(1)			0.0232 U	0.050 U	0.001 U R	0.0622	0.002 U V	0.005 U R	40.2000 V	0.005 U V	0.0090 U V
06/13/89(2)			0.200 U V	0.060 U V	0.010 U A	0.200 U A	0.005 U A	0.0052 A	43.70 A	1.00 U V	0.0100 U A
01/27/87(3)			0.0407 J	0.050 U	NR	0.0564 J	0.002 U	0.005 U	35.9096	NR	0.0090 U
08/17/89(3)			0.200 U V	0.060 U V	0.0100 U A	0.200 U V	0.005 U V	0.005 U V	40.30 V	1.00 U V	0.0100 U R
08/18/89(3)			0.200 U V	0.060 U V	0.0100 U A	0.200 U V	0.005 U V	0.005 U V	40.30 V	1.00 U V	0.0100 U R
10/20/89(4)			0.030 U	0.500 U	0.0117	0.0659	0.002 U	0.004 U	36.30	0.001 U	0.0200 U
10/20/89(4)			0.030 U	0.500 U	0.0061	0.0634	0.002 U	0.0043	37.00	0.001 U	0.0200 U

⁽¹⁾ SS#1 = Amphibole Formation Sandstone #1; CS = Amphibole Formation claystone/siltstone; AL = alluvium; HSU = Hydrostratigraphic Unit

⁽²⁾ Number in parenthesis = the calendar quarter sample was collected.

Notes:

- (1) VALUE QUALIFIERS: NR = Analyte not reported; U = Analyzed but not detected; * = Holding time not met; E = Estimated value; J = Present below detection limit; B = Present in laboratory blank; N = Batch spike not in 80-120% range
- (2) DATA VALIDATION QUALIFIERS: (No validation qualifier indicates data has not been validated); R = Rejected; A = Acceptable with qualifications; V = Valid
- (3) Wells in upper HSU have portion of well screen or entire well screen or entire well screen in upper HSU.
- (4) Wells in lower HSU have entire well screen below boundary between "alluvial" and "bedrock" components of RFI/RI shown in Figure 1-1.
- (5) Wells 1487BR is in lower HSU according to Note (4) above; however, it is screened in weathered SS#5 that subcrops and may be hydrologically connected to upper HSU.

TABLE 2-8B

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Cobalt-Molybdenum)**

Well Designation	Lithology of Screened Interval ^m	Sample Date ^m	Cobalt (Co), diss. mg/l	Copper (Cu), diss. mg/l	Iron (Fe), diss. mg/l	Lead (Pb), diss. mg/l	Lithium (Li), diss. mg/l	Magnesium (Mg), diss. mg/l	Manganese (Mn), diss. mg/l	Mercury (Hg), diss. mg/l	Molybdenum (Mo), diss. mg/l
UPPER HSU											
1587	AL	10/08/87(D)	0.0220 U	0.0088	0.0069 U	NR	NR	10.4154	0.1393	NR	0.0220 U
		10/08/87(4)	0.0200 U	0.0087	0.0069 U	0.0050 U	0.0100 J	10.5314	0.1396	0.0002 U	0.0220 U
		03/01/88(1)	0.0220 U	0.0063 U	0.0285	0.0050 U	0.1000 U	11.1265	0.0394	0.0002 U	0.0220 U
		04/21/88(2)	0.0220 U	0.0115	0.0487	0.0050 U	0.0100 U	10.5472	0.0051 U	0.0002 U	0.0220 U
		08/03/89(3)	0.0290 U	0.0042 J	0.0350 U	NR	NR	7.8672	0.0020 U	NR	0.0270 U
		12/04/89(4)	0.0300 U	0.0250 U	0.100 U	0.0030 U	0.1000 U	10.000	0.0150 U	0.0002	0.1000 U
6286	SS#3	04/09/87(2)	0.0220 U	0.0063 U	0.0069 U	0.0050 U	NR	4.1261	0.0051 U	0.0002 U	0.1000 U
		04/29/87(2)	0.0220 U	0.0063 U	0.0069 U	0.0050 U	NR	4.3072	0.0051 U	0.0002 U	0.0220 U
		07/07/87(3)	0.0220 U	0.0166	0.0272	0.0050 U	NR	8.1709	0.0051 U	0.0008	0.0220 U
		10/16/87(4)	0.0220 U	0.0087	0.1330	0.0050 U	0.030 J	8.6835	0.0051 U	0.0001 J	0.0220 U
		02/18/88(1)	0.0220 U	0.0063 U	0.0078	0.0050 U	0.100 U	9.9492	0.0051 U	0.0002 U	0.0220 U
		04/14/88(2)	0.0220 U	0.0063 U	0.0255	0.0050 U	0.0100 U	11.5102	0.0051	0.0002 U	0.0220 U
		07/15/88(3)	0.0220 U	0.0063 U	0.0409	0.0050 U	NR	11.2686	0.0051 U	0.0002 U*	0.0220 U
		10/20/88(4)	0.0220 U	0.0276	0.0396	0.0050 U	NR	12.4129	0.0051 U	0.0002 U	0.0220 U
		01/23/89(1)	0.0290 U V	0.0040 U V	0.0490 V	0.0015 V	NR	11.3000 V	0.0020 U V	0.0002 U A	0.0270 U V
		06/10/89(2)	0.0500 U A	0.0250 U R	0.1000 U V	0.0050 U A	0.100 U V	11.4000 A	0.0150 U V	0.0002 U V	0.1000 U
		07/20/89(3)	0.0290 U	0.0040 U	0.0350 U	NR	NR	11.7349	0.0020 U	NR	0.0270 U
		10/19/89(4)	0.0200 U	0.0200 U	0.1800	0.0025	0.0410	10.4000	0.0100 U	0.0002 U	0.5000 U
1287BR	CS	02/26/88(1)	0.0220 U	0.0088	0.0169	0.0050 U	0.1100	7.1516	0.0447	0.0002 U	0.0220 U
		04/21/88(2)	0.0220 U	0.0098	0.0811	0.0050 U	0.1000 U	7.5445	0.0078	0.0002 U	0.0220 U

TABLE 2-8B

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUS
(Cobalt-Molybdenum)
(Continued)**

Well Designation	Lithology of Screened Interval ¹⁰	Sample Date ¹⁰	Cobalt (Co), diss. mg/l	Copper (Cu), diss. mg/l	Iron (Fe), diss. mg/l	Lead (Pb), diss. mg/l	Lithium (Li), diss. mg/l	Magnesium (Mg), diss. mg/l	Manganese (Mn), diss. mg/l	Mercury (Hg), diss. mg/l	Molybdenum (Mo), diss. mg/l
UPPER HSU											
2387BR	SS #1	07/26/88(3)	0.0220 U	0.0076	0.2085	0.0050 U	NR	7.8634	0.0227	0.0002 U	0.0220 U
		10/22/87(4)	0.0220 U	0.0063 U	0.1942	NR	NR	12.8861	0.2422	NR	0.0220 U
		03/03/88(1)	0.0220 U	0.0063 U	0.0333	0.0050	0.100 U	13.8849	0.1289	0.0002 U	0.0220 U
		04/29/88(2)	0.0220 U	0.0063 U	0.0135	0.0050 U	0.100 U	13.4011	0.0720	0.0002 U	0.0220 U
		11/04/88(4)	0.0220 U	0.0063 U	0.0238	0.0050 U	NR	12.9893	0.0178	0.0002 U	0.0220 U
		02/07/89(1)	0.0290 U	0.0040 U	0.0350 U	0.0010 U	NR	12.9433	0.0043 J	0.0002 U	0.0270 U
		12/04/89(4)	0.0500 U	0.0250 U	0.1000 U	0.0030 U	0.100 U	13.4000	0.0163	0.0002 U	0.1000 U
		10/22/87(4)	0.0220 U	0.0063 U	4.3470	NR	NR	8.0261	0.3485	NR	0.0220 U
		03/04/88(1)	0.0220 U	0.0063 U	0.0171	0.0050 U	0.0100 U	7.8072	0.0051 U	0.0002 U	0.0220 U
		05/12/88(2)	0.0220 U	0.0126	0.0220	0.0050 U	NR	7.3872	0.0051 U	0.0002 U	0.0220 U
3087BR	SS #1/CS	08/16/88(3)	0.0220 U	0.0063 U	0.0319	0.0050 U	NR	7.1069	0.0051 U	0.0002 U	0.0220 U
		02/15/89(1)	0.0290 U	0.0040 U	0.0767 J	0.0111	NR	8.7065	0.0023 J	0.0002 U	0.027 U
		11/02/89(4)	0.0200 U	0.0200 U	0.0544	0.0020 U	0.0130	7.9200	0.0100 U	0.0002 U	0.0500 U
		11/06/87(4)	0.0220 U	0.0109	0.0261	NR	NR	9.6752	0.3544	NR	0.0220 U
		03/10/88(1)	0.0220 U	0.0063 U	0.0122	0.0050 U	0.1000 U	8.5566	0.0916	0.0002 U	0.0220 U
		05/05/88(2)	0.0220 U	0.0065 U	0.0303	0.0050 U	NR	8.5449	0.0486	0.0002 U	0.0220 U
		08/19/88(3)	0.0220 U	0.0063 U	0.0295	0.0050 U	NR	8.6749	0.0499	0.0002 U	0.0220 U
		02/15/89(1)	0.0290 U	0.0040 U	0.0373 J	0.0010 U	NR	10.3045	0.1653	0.0002 U	0.0270 U
		11/10/89(4)	0.0500 U V	0.025 U A	0.1000 U V	0.0030 U V	0.0100 U V	10.5000 A	0.0419 V	0.0002 U V	0.1000 U V

TABLE 2-8B

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Cobalt-Molybdenum)**
(Continued)

Well Designation	Lithology of Screened Interval ^a	Sample Date ^b	Cobalt (Co), diss. mg/l	Copper (Cu), diss. mg/l	Iron (Fe), diss. mg/l	Lead (Pb), diss. mg/l	Lithium (Li), diss. mg/l	Magnesium (Mg), diss. mg/l	Manganese (Mn), diss. mg/l	Mercury (Hg), diss. mg/l	Molybdenum (Mo), diss. mg/l
LOWER HSU											
3486	SS#3	03/17/87(1)	0.0220 U	0.0063 U	0.6726	0.005 U	NR	62.6727	0.0718	0.0002 U	0.0220 U
		04/06/87(2)	0.0220 U	0.0063 U	0.4421	0.005 U	NR	65.0379	0.1019	0.0002 U	0.0220 U
		06/02/87(2)	0.0220 U	0.0096	1.0040	0.005 U	NR	72.6015	0.0159	0.0002 U	0.0220 U
		07/28/87(3)	0.0220 U	0.0063 U	1.5312	0.005 U	NR	72.7323	0.1205	0.0002 U	0.0220 U
		10/17/87(4)	0.0220 U	0.0063 U	1.4362	0.005 U	0.2	67.4890	0.1445	0.0001 J	0.0220 U
		03/03/88(1)	0.0220 U	0.0092	0.1353	0.005 U	0.1 U	2.0699	0.0070	0.0002 U	0.0509
		05/03/88(2)	0.0220 U	0.0124	1.5495	0.005 U	NR	92.1996	0.0692	0.0002 U	0.0220 U
		11/04/88(4)	0.0220 U	0.0063 U	2.1817	0.005 U	NR	68.6772	0.1348	0.0002 U	0.0220 U
		02/09/89(1)	0.029 U	0.004 U	2.1491	0.0011 J	NR	73.7748	0.0957	0.0002 U	0.027 U
		05/06/87(2)	0.0220 U	0.0130 U	0.2441	0.0050 U	NR	31.2705	0.5351	0.0002 U	0.1035
		10/27/87(4)	0.0220 U	0.0092	0.0955 U	0.0050	0.040 J	17.0217	0.1816	0.0002 U	0.0497
1487BR	SS#5	03/11/88(1)	0.0220 U	0.0063 U	0.0227	0.0050 U	0.100 U	17.6838	0.0432	0.0002 U	0.0256
		05/12/88(2)	0.0220 U	0.0101	0.0228	0.0050 U	NR	18.6570	0.0125	0.002 U	0.0220 U
		12/04/89(4)	0.0200 U	0.0200 U	0.0845	0.0032	0.051	17.1000	0.0157	0.0002 U	0.5000 U
		10/13/87(4)	0.0220 U	0.0090	0.0599	0.004 J	0.04 J	0.1458	0.0051 U	0.0002 U	0.0220 U
		03/01/88(1)	0.0220 U	0.0118	0.0366	0.005 U	0.06 J	1.3191	0.0051 U	0.0002 U	0.0220 U
		04/22/88(2)	0.0220 U	0.0064	0.0172	0.005 U	0.06 J	4.0380	0.0051 U	0.0002 U	0.0220 U
		06/09/88(3)	0.0220 U	0.0090	0.0131 U	0.005 U	NR	7.5092	0.0051 U	0.0002 U	0.0220 U
		01/25/89(1)	0.029 U	0.0048 J	0.035 U	0.001 U	NR	12.9274	0.002 U	0.0002 U	0.027 U
		01/25/89(1D)	0.029 U	0.0265	0.0730 U	0.001 U	NR	11.8875	0.002 U	0.0002 U	0.027 U

TABLE 2-8B

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Cobalt-Molybdenum)
(Continued)**

Well Designation	Lithology of Screened Interval ^a	Sample Date ^b	Cobalt (Co), diss. mg/l	Copper (Cu), diss. mg/l	Iron (Fe), diss. mg/l	Lead (Pb), diss. mg/l	Lithium (Li), diss. mg/l	Magnesium (Mg), diss. mg/l	Manganese (Mn), diss. mg/l	Mercury (Hg), diss. mg/l	Molybdenum (Mo), diss. mg/l
LOWER HSU											
1687BR	SS #3	08/05/89(3)	0.0290 U	0.0040 U	0.0350 U	NR	NR	11.8479	0.0020 U	NR	0.0270 U
		11/28/89(4)	0.0590 U	0.0250 U	0.100 U	0.0050 U	0.102	1630	0.0150 U	0.0002 U	0.100 U
		10/17/87(4)	0.0220 U	0.0063 U	0.1731	NR	NR	2.6440	0.0051 U	NR	0.0250
		03/01/88(1)	0.0220 U	0.0074	0.0644	0.0050 U	0.050 J	3.5134	0.0051 U	0.0002 U	0.0295
		04/22/88(2)	0.0220 U	0.0063 U	0.0186	0.0050 U	0.100 U	4.7883	0.0051 U	0.0002 U	0.0220 U
		08/10/88(3)	0.0020 U	0.0108	0.0219	0.0050 U	NR	4.9487	0.0072	0.0002 U	0.0225
		02/07/89(1)	0.0290 U	0.0040 U	0.0652 J	0.0010 U	NR	6.0096	0.0063 J	0.0002 U	0.0270 U
		08/03/89(3)	0.0290 U	0.0397	0.0350 U	NR	NR	6.5807	0.0121 J	NR	0.0270 U
		09/11/89(3)	0.0590 U	0.0250 U	0.1000 U	0.0020 U	0.0100 U	5.7300	0.0092	0.0002 U	0.1000 U
		11/06/89(4)	0.0590 U	0.0250	0.1000 U	0.0030 U	0.100 U	5.7500	0.0092	0.0002 U	0.1000 U
1887BR	SS #4	03/07/88(1)	0.0220 U	0.0379	0.0631	0.0050 U	0.1000 U	1.1415	0.1154	0.0002 U	0.0286
2287BR	CS	03/08/88(1)	0.0220 U	0.0063 U	0.0230	0.005 U	0.1 U	6.4239	0.0319	0.0002 U	0.0843
		05/03/88(2)	0.0220 U	0.0122	0.0423	0.005 U	NR	7.8109	0.0439	0.0002 U	0.0764
		11/09/88(4)	0.0220 U	0.0063 U	0.0080	NR	NR	12.5151	0.0426	0.0002 U	0.0582
		02/09/89(1)	0.029 U	0.004 U	0.0351 J	0.001 U	NR	16.8731	0.0651	0.0002 U	0.0545
		11/10/89(4)	0.0500 U V	0.025 U A	0.100 U V	0.003 V A	0.100 U V	21.50 A	0.0504 V	0.0002 U	0.100 U V
		11/13/89(4)	0.0500 U V	0.025 V A	0.100 U V	0.003 J A	0.100 U V	21.50 A	0.0504 V	0.0002 U	0.100 U V
		03/15/88(1)	0.0220 U	0.0063 U	0.0143	0.0050 U	0.100 U	1.7166	0.0092	0.0002 U	0.0251
		05/12/88(2)	0.0220 U	0.0463	0.1786	0.0050 U	NR	3.1309	0.0304	0.0002 U	0.1347
		02/20/89(1)	0.0290 U	0.0127 J	0.0983 J	0.0010 U	NR	6.2484	0.0295	0.0002 U	0.0902

Phase II R/T/03 Work Plan (Recheck) - 903 Pad, Mound, and East Trench Area, Draft Final
Rocky Flats Plant, Golden, Colorado, January 31, 1991
21578/RT/28B 02-04-91/RT/72

TABLE 2-8B

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Cobalt-Molybdenum)
(Continued)**

Well Designation	Lithology of Screened Interval ^a	Sample Date ^b	Cobalt (Co), diss. mg/l	Copper (Cu), diss. mg/l	Iron (Fe), diss. mg/l	Lead (Pb), diss. mg/l	Lithium (Li), diss. mg/l	Magnesium (Mg), diss. mg/l	Manganese (Mn), diss. mg/l	Mercury (Hg), diss. mg/l	Molybdenum (Mo), diss. mg/l
LOWER HSU											
3087BR	CS	01/22/88(1)	0.0220 U	0.0063 U	0.0414	0.005 U	0.01 U	2.2105	0.0060	0.0002 U	0.0220 U
		03/03/88(1)	0.0220 U	0.0063 U	0.0167	0.005 U	0.01 U	1.9955	0.0071	0.0002 U	0.0248
		04/22/88(2)	0.0220 U	0.0063 U	0.0679	0.005 U	0.01 U	2.9772	0.0087	0.0002 U	0.0220 U
		06/09/88(3)	0.0220 U	0.0063 U	0.0090	0.005 U	NR	3.1945	0.0124	0.0002 U	0.0220 U
		02/01/89(2)	0.029 U	0.020 J	0.0392	0.001 U	NR	2.8943 J	0.0117 J	0.002 U	0.027 U
		12/08/89(4)	0.0200 U	0.0200 U	0.140	0.0035	0.0417	3.41	0.0132	0.0002 U	0.500 U
		12/12/89(4)	0.0200 U	0.0200 U	0.140	0.0035	0.0417	3.41	0.0132	0.0002 U	0.500 U
		02/09/90(2)	0.0500 U	0.0250 U	0.100 U	0.005 U	0.100 U	5.00 U	0.0385	0.0002 U	0.100 U
		10/29/87(4)	0.0220 U	0.0141	0.1701	NR	NR	0.1157	0.0051	NR	0.0568
		05/12/88(2)	0.0220 U	0.0121	0.0906	0.005 U	NR	0.3730	0.0051 U	0.0002 U	0.0408
3187BR	SS#3	08/25/88(3)	0.0220 U	0.0106	0.0239	0.005 U	NR	0.7221	0.0051 U	0.0002 U	0.0440
		02/22/89(2)	0.0290 U	0.004 U	0.0371 J	0.001 U	NR	1.1088 J	0.0024 J	0.0002 U	0.027 U
		05/10/88(1)	0.0220 U	0.0063 U	0.9745	0.0050 U	0.220	63.8066	0.1477	0.0002 U	0.0243
		05/12/22(2)	0.0220 U	0.0125	0.0874	0.0050 U	NR	2.9255	0.0105	0.0002 U	0.0323
		05/12/88(1)	0.0220 U	0.0128	0.0802	0.0050 U	NR	2.8998	0.0106	0.0002 U	0.0338
		02/20/89(1)	0.0290 U	0.0044 J	0.0764 J	0.0010 U	NR	4.1140 J	0.0099 J	0.0002 U	0.0270 U
		12/13/89(4)	0.0500 U	0.0250 U	0.100 U	0.0026	5.000 U	5.0000 U	0.0130 U	0.0002 U	0.1000 U
		11/24/87(4)	0.0220 U	0.0133	0.0899	0.0050 U	NR	2.3647	0.0493	0.0002 U	0.0630
		02/26/88(1)	0.0220 U	0.0063	0.0286	0.0050 U	0.060 J	5.2957	0.1277	0.0002 U	0.0582
		04/19/88(2)	0.0220 U	0.0096	0.1218	0.0050 U	0.060 J	7.0306	0.2899	0.0002 U	0.0567
3487BR	CS	01/22/88(1)	0.0220 U	0.0063 U	0.0414	0.005 U	0.01 U	2.2105	0.0060	0.0002 U	0.0220 U
		03/03/88(1)	0.0220 U	0.0063 U	0.0167	0.005 U	0.01 U	1.9955	0.0071	0.0002 U	0.0248
		04/22/88(2)	0.0220 U	0.0063 U	0.0679	0.005 U	0.01 U	2.9772	0.0087	0.0002 U	0.0220 U
		06/09/88(3)	0.0220 U	0.0063 U	0.0090	0.005 U	NR	3.1945	0.0124	0.0002 U	0.0220 U
		02/01/89(2)	0.029 U	0.020 J	0.0392	0.001 U	NR	2.8943 J	0.0117 J	0.002 U	0.027 U
		12/08/89(4)	0.0200 U	0.0200 U	0.140	0.0035	0.0417	3.41	0.0132	0.0002 U	0.500 U
		12/12/89(4)	0.0200 U	0.0200 U	0.140	0.0035	0.0417	3.41	0.0132	0.0002 U	0.500 U
		02/09/90(2)	0.0500 U	0.0250 U	0.100 U	0.005 U	0.100 U	5.00 U	0.0385	0.0002 U	0.100 U
		10/29/87(4)	0.0220 U	0.0141	0.1701	NR	NR	0.1157	0.0051	NR	0.0568
		05/12/88(2)	0.0220 U	0.0121	0.0906	0.005 U	NR	0.3730	0.0051 U	0.0002 U	0.0408
4587BR	SS#5	08/25/88(3)	0.0220 U	0.0106	0.0239	0.005 U	NR	0.7221	0.0051 U	0.0002 U	0.0440
		02/22/89(2)	0.0290 U	0.004 U	0.0371 J	0.001 U	NR	1.1088 J	0.0024 J	0.0002 U	0.027 U
		05/10/88(1)	0.0220 U	0.0063 U	0.9745	0.0050 U	0.220	63.8066	0.1477	0.0002 U	0.0243
		05/12/22(2)	0.0220 U	0.0125	0.0874	0.0050 U	NR	2.9255	0.0105	0.0002 U	0.0323
		05/12/88(1)	0.0220 U	0.0128	0.0802	0.0050 U	NR	2.8998	0.0106	0.0002 U	0.0338
		02/20/89(1)	0.0290 U	0.0044 J	0.0764 J	0.0010 U	NR	4.1140 J	0.0099 J	0.0002 U	0.0270 U
		12/13/89(4)	0.0500 U	0.0250 U	0.100 U	0.0026	5.000 U	5.0000 U	0.0130 U	0.0002 U	0.1000 U
		11/24/87(4)	0.0220 U	0.0133	0.0899	0.0050 U	NR	2.3647	0.0493	0.0002 U	0.0630
		02/26/88(1)	0.0220 U	0.0063	0.0286	0.0050 U	0.060 J	5.2957	0.1277	0.0002 U	0.0582
		04/19/88(2)	0.0220 U	0.0096	0.1218	0.0050 U	0.060 J	7.0306	0.2899	0.0002 U	0.0567

TABLE 2-8B

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Cobalt-Molybdenum)
(Concluded)**

Well Designation	Lithology of Screened Interval ^a	Sample Date ^a	Cobalt (Co), dis. mg/l	Copper (Cu), dis. mg/l	Iron (Fe), dis. mg/l	Lead (Pb), dis. mg/l	Lithium (Li), dis. mg/l	Magnesium (Mg), dis. mg/l	Manganese (Mn), dis. mg/l	Mercury (Hg), dis. mg/l	Molybdenum (Mo), dis. mg/l
LOWER HSU											
		07/22/88(3)	0.0220 U	0.0063 U	0.0264	0.0050 U	NR	8.7134	0.3414	NR	0.0270
		01/23/89(1)	0.0250 U V	0.0040 U V	0.0350 U V	0.0019 U V	NR	10.2000 V	0.4000 V	0.0002 U A	0.0270 U V
		06/13/89(2)	0.0500 U R	0.0250 U R	0.1000 U V	0.0050 U A	0.100 U V	13.3000 A	0.3320 V	0.0002 U V	0.1000 U V
		07/27/89(3)	0.0250 U	0.0041 J	0.0350 U	NR	NR	9.7787	0.3280	NR	0.0270 U
		08/17/89(3)	0.0500 U V	0.0250 U V	0.1000 U V	0.0030 U V	0.100 U V	10.5000 V	0.2770 V	0.0002 U V	0.1000 U V
		08/18/89(3)	0.0500 U V	0.0250 U V	0.1000 U V	0.0030 U V	0.100 U V	10.5000 V	0.2770 V	0.0002 U V	0.1000 U V
		10/20/89(4)	0.0200 U	0.0200 U	0.2440	0.0030	0.049	9.6100	0.2760	0.0002 U	0.5000 U
		10/20/89(D)	0.0200 U	0.0200 U	0.2840	0.0020 U	0.051	9.3300	0.2880	0.0002 U	0.5000 U

^a SS#1 - Arapahoe Formation Sandstone #1; CS - Arapahoe Formation claystone/siltstone; AL - alluvium; HSU - Hydrostratigraphic Unit
^a Number in parenthesis - the calendar quarter sample was collected.

Notes:

- (1) VALUE QUALIFIERS: NR - Analyte not reported; U - Analyzed but not detected; * - Holding time not met; E - Estimated value; J - Present below detection limit; B - Present in laboratory blank; N - Batch spike not in 80-120% range
- (2) DATA VALIDATION QUALIFIERS: (No validation qualifier indicates data has not been validated); R - Rejected; A - Acceptable with qualifications; V - Valid
- (3) Wells in upper HSU have portion of well screen or entire well screen or entire well screen in upper HSU.
- (4) Wells in lower HSU have entire well screen below boundary between "alluvial" and "bedrock" components of RFI/RI shown in Figure 1-1.
- (5) Wells 1487BR is in lower HSU according to Note (4) above; however, it is screened in weathered SS#5 that subcrops and may be hydrologically connected to upper HSU.

TABLE 2-8C

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Nickel-Zinc)**

Well Designation	Lithology of Screened Interval ^{1a}	Sample Date ^{2a}	Nickel (Ni), diss. mg/l	Potassium (K), diss. mg/l	Selenium (Se), diss. mg/l	Silver (Ag), diss. mg/l	Sodium (Na), diss. mg/l	Strontium (Sr), diss. mg/l	Thallium (Tl), diss. mg/l	Tin (Sn), diss. mg/l	Zinc (Zn), diss. mg/l
UPPER HSU											
1587	AL	10/08/87(D)	0.0370 U	NR	NR	0.0076 U	7.6207	0.4800	NR	NR	0.0200 U
		10/08/87(4)	0.0370 U	1.4900	0.0050 U	0.0076 U	9.3217	0.4795	0.0100 U	NR	0.0200 U
		03/01/88(1)	0.0370 U	0.8000	0.0050 U	0.0424	11.9562	0.4859	0.0100 U	NR	0.0361
		04/21/88(2)	0.0370 U	0.7000	0.0050 U	0.0076 U	8.5874	0.4283	0.0100 U	NR	0.0712
		08/03/89(3)	0.0220 U	NR	NR	0.0040 U	9.6778	0.3357	NR	NR	0.0080 U
		12/04/89(4)	0.0400 U	5.0000 U	0.0050 U	0.0100 U	10.6000	0.4880	0.0100 U	0.100 U	0.0200 U
6286	SS #3	04/09/87(2)	0.0370 U	13.0000	0.0060	0.0076 U	53.4960	0.4131	0.0100 U	NR	0.0500
		04/29/87(2)	0.0370 U	10.0000	0.0400	0.0076 U	58.5839	0.3812	0.0100 U	NR	0.0200 U
		07/07/87(3)	0.0370	8.2000	0.030	0.0076 U	60.8007	0.4878	0.0100 U	NR	0.0200 U
		10/16/87(4)	0.1041	9.1000	0.0270	0.0076 U	51.3986	0.3823	0.0100 U	NR	0.0200 U
		02/18/88(1)	0.0539	5.9000	0.0620	0.0076 U	49.7036	0.4234	0.0100 U	NR	0.0200 U
		04/14/88(2)	0.0485	4.2000	0.0710	0.0076 U	47.0577	0.4104	0.0100 U	NR	0.0200 U
		07/15/88(3)	0.0370 U	4.1000	0.0410	0.0076 U	53.1023	0.4450	0.0100 U	NR	0.0291
		10/20/88(4)	0.0370 U	4.8000	0.0440	0.0076 N U	54.8659	0.5031	0.0100 U	NR	0.0918
		01/23/89(1)	0.0220 U V	3.8600 V	0.0565 V	0.0040 U V	54.8000 V	0.4510 V	0.0010 U V	NR	0.0080 U V
		06/10/89(2)	0.0400 U A	5.0000 U A	0.0616 V	0.0100 U A	51.4000 V	1.0000 U V	0.0100 U A	0.1000 U V	0.0200 U A
		07/20/89(3)	0.0220 U	NR	NR	0.0040 U	52.2509	0.5188	NR	NR	0.0080 U
		10/19/89(4)	0.0200 U	3.2200	0.0550	0.0300 U	43.3000	0.4110	0.0030 U	1.0000 U	0.0291
1287BR	CS	02/26/88(1)	0.1154	1.3000	0.0020 J	0.0076 U	172.5999	0.2467	0.0100 U	NR	0.0200 U
		04/21/88(2)	0.0610	0.8000	0.0050 U	0.0076 U	179.5822	0.2582	0.0050 U	NR	0.0553
		07/26/88(3)	0.0422	1.1000	0.0050 U	0.0076 U	193.4917	0.2735	0.0100 U	NR	0.0200 U

TABLE 2-8C

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Nickel-Zinc)
(Continued)**

Well Designation	Lithology of Screened Interval ^a	Sample Date ^b	Nickel (Ni), diss. mg/l	Potassium (K), diss. mg/l	Selenium (Se), diss. mg/l	Silver (Ag), diss. mg/l	Sodium (Na), diss. mg/l	Strontium (Sr), diss. mg/l	Thallium (Tl), diss. mg/l	Tin (Sn), diss. mg/l	Zinc (Zn), diss. mg/l
UPPER HSU											
2387BR	SS #1	10/22/87(4)	0.0370 U	NR	NR	0.0076 U	8.8855	0.5299	NR	NR	0.0301
		03/08/88(1)	0.0370 U	1.7000	0.0050 U	0.0076 U	9.6792	0.6205	0.0100 U	NR	0.0200 U
		04/29/88(2)	0.0558	1.6000	0.0050 U	0.0076 U	8.0978	0.5278	0.0100 U	NR	0.0221
		11/04/88(4)	0.0370 U	1.2000	0.0050 U	0.0076 U	10.9816	0.6030	0.0100 U	NR	0.0237
		02/07/89(1)	0.0347 J	1.6500 J	0.0011 J	0.0040 U	9.5848	0.5680	0.0010 U	NR	0.0082 J
		12/04/89(4)	0.0492	5.0000 U	0.0050 U	0.0100 U	9.2300	0.6220	0.0100 U	0.1000 U	0.0200 U
		10/22/87(4)	0.0370 U	NR	NR	0.0076 U	9.3252	0.3112	NR	NR	0.0886
2587BR	SS #1	03/04/88(1)	0.0370 U	1.1000	0.0050 U	0.0076 U	11.7683	0.2998	0.0100 U	NR	0.0200 U
		05/12/88(2)	0.0370 U	0.6000	0.0050 U	0.0076 U	11.0605	0.2345	0.0100 U	NR	0.0200 U
		08/16/88(3)	0.0370 U	0.5000	0.0050 U	0.0076 U	13.3006	0.2606	0.0100 U	NR	0.0264
		02/15/89(1)	0.0220 U	0.6000 J	0.0014 J	0.0040 U	13.0472	0.3480	0.0010 U	NR	0.0195 J
		11/02/89(4)	0.0200 U	0.7040	0.0020 U	0.0300 U	10.9000	0.2940	0.0030	1.000 U	0.0100 U
		11/06/87(4)	0.0548	NR	NR	0.0076 U	11.0671	0.3658	NR	NR	0.0365
		03/10/88(1)	0.0370 U	0.700	0.0050 U	0.0076 U	9.3131	0.2984	0.0100 U	NR	0.0225
3687BR	SS #1/CS	05/05/88(2)	0.0370 U	0.900	0.0050 U	0.0076 U	9.4793	0.2872	0.0100 U	NR	0.0200 U
		08/19/88(3)	0.0370 U	0.900	0.0050 U	0.0076 U	8.8509	0.2950	0.0100 U	NR	0.0200 U
		11/10/89(4)	0.0400 U V	5.000 U V	0.0050 U A	0.0100 U V	9.7400 A	0.3360 V	0.0700 U V	0.100 U V	0.0200 U A
		02/15/89(1)	0.0347 J	1.5000 J	0.0011 J	0.0040 U	14.2014	0.4245	0.0010 U	NR	0.0300

TABLE 2-8C

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Nickel-Zinc)
(Continued)**

Well Designation	Lithology of Screened Interval ^{1a}	Sample Date ^{1b}	Nickel (Ni), diss. mg/l	Potassium (K), diss. mg/l	Selenium (Se), diss. mg/l	Silver (Ag), diss. mg/l	Sodium (Na), diss. mg/l	Strontium (Sr), diss. mg/l	Thallium (Tl), diss. mg/l	Tin (Sn), diss. mg/l	Zinc (Zn), diss. mg/l
LOWER HSU											
3486	SS #3	03/17/87(1)	0.0370 U	8.6	0.005 U	0.0076 U	227.7501	2.8304	0.01 U	NR	0.06
		04/06/87(2)	0.0370 U	8.0	0.005 U	0.0076 U	220.6902	2.8040	0.01 U	NR	0.08
		06/02/87(2)	0.0370 U	8.2	0.005 U	0.0076 U	221.9862	2.8541	0.01 U	NR	0.02 U
		07/28/87(3)	0.0370 U	3.2	0.005 U	0.0076 U	231.0510	2.9499	0.01 U	NR	0.02004
		10/17/87(4)	0.0370 U	10.9	0.005 U	0.0076 U	221.9791	2.7259	0.01 U	NR	0.02 U
		03/03/88(1)	0.0370 U	3.1	0.005 U	0.0076 U	76.7449	0.2005	0.01 U	NR	0.034
		05/03/88(2)	0.0370 U	8.9	0.005 U	0.0076 U	232.1001	2.8410	0.01 U	NR	0.02 U
		11/04/88(4)	0.0370 U	7.5	NR	0.0076 U	224.1979	3.1113	0.01 U	NR	0.02 U
4086	CS	02/09/89(1)	0.022 U	7.9	0.001 U	0.004 U	226.5604	3.0086	0.001 U	NR	0.02 U
		05/06/87(2)	0.0551	6.0	0.005 U	0.0076 U	134.5506	1.4881	0.0100 U	NR	0.050
		10/27/87(4)	0.0468	3.9000	0.005	0.0076 U	101.0152	0.8204	0.0100 U	NR	0.0229
		03/11/88(1)	0.0370 U	5.3000	0.004 J	0.0291	99.9352	0.8327	0.100 U	NR	0.0269
		12/04/89(4)	0.0200 U	3.8000	0.002 U	0.0300 U	102.0000	0.7890	0.0030 U	1.0000 U	0.0207
		05/12/88(2)	0.0378	3.8000	0.0050 U	0.0076 U	90.0279	0.7155	0.0100 U	NR	0.0380
1487BR	SS #5	10/13/87(4)	0.0370 U	12.3	0.011	0.0076 U	76.9625	1.4379	0.01 U	NR	0.02 U
		03/01/88(1)	0.0370 U	8.0	0.012	0.0076 U	77.9638	0.3449	0.01 U	NR	0.0295
		04/22/88(2)	0.0370 U	7.9	0.013	0.0073 U	84.0615	0.3095	0.01 U	NR	0.0200 U
		08/09/88(3)	0.0370 U	6.7	0.014	0.0076 U	85.1056	0.3517	0.01 U	NR	0.0255
		01/25/89(1)	0.022 U	4.750 B	0.016	0.004 U	7.4038	0.6339	0.001 U	NR	0.0109 J
		01/25/89(1)	0.022 U	4.820 J	0.066	.0044 J	81.7647	0.6635	0.001 U	NR	0.008 U

TABLE 2-8C

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Nickel-Zinc)
(Continued)**

Well Designation	Lithology of Screened Interval ^(a)	Sample Date ^(b)	Nickel (Ni), diss. mg/l	Potassium (K), diss. mg/l	Selenium (Se), diss. mg/l	Silver (Ag), diss. mg/l	Sodium (Na), diss. mg/l	Strontium (Sr), diss. mg/l	Thallium (Tl), diss. mg/l	Tin (Sn), diss. mg/l	Zinc (Zn), diss. mg/l
LOWER HSU											
1687BR	SS #3	08/03/89(3)	0.0220 U	NR	NR	0.0040 U	80.3288	0.4839	NR	NR	0.0080 U
		11/28/89(4)	0.0400 U	5.00 U	0.0106	0.0100 U	77.20	1.00 U	0.0100 U	0.100 U	0.0200 U
		10/17/87(4)	0.0370 U	NR	NR	0.0076 U	60.8289	0.2522	NR	NR	0.0200 U
		03/01/88(1)	0.0370 U	8.1000	0.0020 J	0.0076 U	67.6220	0.2834	0.01400 U	NR	0.0200 U
		04/22/88(2)	0.0370 U	4.2000	0.0040 J	0.0076 U	66.4353	0.3042	0.0100 U	NR	0.0200 U
		08/10/88(3)	0.0370 U	4.0000	0.0050 U	0.0076 U	72.4248	0.02867	0.0100 U	NR	0.0200 U
		02/27/89(1)	0.0220 U	3.2500 J	0.0014 J	0.0040 U	73.5594	0.3652	0.0010 U	NR	0.0170 J
		08/03/89(3)	0.0220 U	NR	NR	0.0040 U	76.0211	0.3603	NR	NR	0.0169 J
		11/06/89(4)	0.0400 U	5.0000 U	0.0050 U	0.100 U	66.0000	0.3020	0.0100 U	0.1000 U	0.0315
		09/11/89(3)	0.0400 U	5.000 U	0.0050 U	0.0100 U	66.0000	0.3020	0.0100 U	0.1000 U	0.0315
1887BR	SS #4	03/08/88(1)	0.0661	0.8	0.003	0.0103	22.8139	0.1107	0.010 U	NR	0.0279
2287BR	CS	03/08/88(1)	0.0372	14	0.005 U	0.0076 U	88.6237	0.4659	0.010 U	NR	0.0339
		05/03/88(2)	0.0370 U	13.3	0.005 U	0.0076 U	100.1605	0.4906	0.010 U	NR	0.0200 U
		11/09/88(4)	0.0370 U	9.2	0.005 U	0.0076 U	135.7162	0.7709	NR	NR	0.0200 U
		02/09/89(1)	0.022 U	10.7	0.001 U	0.0064	148.1065	0.8774	0.001 U	NR	0.0080 U
		11/10/89(4)	0.0400 U V	8.00 V	0.005 U A	0.0100 U V	159.00 A	0.934 V	0.001 U V	0.100 U V	0.0384 A
		11/13/89(4)	0.0400 U V	8.00 V	0.005 U A	0.0100 U V	159.00 A	0.934 V	0.001 U V	0.100 U V	0.0384 A
		03/15/88(1)	0.0370 U	14.000	0.003 J	0.0076 U	19.3060	0.1373	0.0100 U	NR	0.0200 U
		05/12/88(2)	0.0370 U	5.200	0.005 U	0.0076 U	92.0039	0.2427	0.0010 U	NR	0.0489
		02/20/89(1)	0.0220 U	5.600	0.002 J	0.0040 U	142.8783	0.4937	0.0010 U	NR	0.0364

TABLE 2-8C

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Nickel-Zinc)
(Continued)**

Well Designation	Lithology of Screened Interval ^a	Sample Date ^a	Nickel (Ni), diss. mg/l	Potassium (K), diss. mg/l	Selenium (Se), diss. mg/l	Silver (Ag), diss. mg/l	Sodium (Na), diss. mg/l	Strontium (Sr), diss. mg/l	Thallium (Tl), diss. mg/l	Tin (Sn), diss. mg/l	Zinc (Zn), diss. mg/l
LOWER HSU											
3087BR	CS	01/22/88(1)	0.0370 U	5.3	0.005 U	0.0076 U	85.6715	0.2057	0.010 U	NR	0.0280
		03/03/88(1)	0.0370 U	4.9	0.005 U	0.0076 U	120.1536	0.2415	0.010 U	NR	0.0224
		04/22/88(2)	0.0370 U	3.7	0.005 U	0.0076 U	132.7649	0.2789	0.010 U	NR	0.0200 U
		08/09/88(3)	0.0370 U	3.1	0.005 U	0.0076 U	134.1108	0.2764	0.010 U	NR	0.0200 U
		02/01/89(1)	0.022 U	2.9 J	0.001 U	0.004 U	118.557	0.2621	0.001 U	NR	0.008 U
		12/08/89(4)	0.0200 U	2.66 J A	0.0020 U	0.0300 U	123.00	0.288	0.0150 U	1.0 U	0.0100 U
		12/12/89(4)	0.0200 U	2.66 J A	0.0020 U	0.0300 U	123.00	0.288	0.0150 U	1.0 U	0.0100 U
		02/09/90(1)	0.0400 U	5.00 U	0.0050 U	0.0100 U	124.00	1.00 U	0.0100 U	0.100 U	0.0200 U
		10/29/87(4)	0.0370 U	NR	NR	0.0076 U	78.5306	0.1768	NR	NR	0.0227
		05/12/88(2)	0.0370 U	3.0	0.005 U	0.0076 U	69.2078	0.1697	0.010 U	NR	0.0258
3487BR	CS	08/25/88(3)	0.0370 U	3.0	0.005 U	0.0076 U	72.9478	0.2119	0.010 U	NR	0.0306
		02/22/89(1)	0.0220 U	2.45	0.001 U	0.0040 U	70.2818	0.1968 J	0.001 U	NR	0.0207
		03/09/88(1)	0.0370 U	7.600	0.005 U	0.0076 U	219.1668	2.5972	0.0100 U	NR	0.0200 U
		05/12/88(2)	0.0370 U	2.500	0.005 U	0.0076 U	74.7950	0.2137	0.0100 U	NR	0.0334
		05/12/88(D)	0.0370 U	2.500	0.005 U	0.0076 U	67.5259	0.1978	0.0100 U	NR	0.0294
		02/20/89(1)	0.0220 U	2.800 J	0.001 U	0.0040 U	78.4420	0.2345	0.0010 U	NR	0.0184 J
4587BR	SS#5	12/13/89(4)	0.0400 U	5.000 U	0.0023	0.0100 U	70.4000	0.2420	0.0030 U	1.0000 U	0.0200 U
		11/24/87(4)	0.0370 U	NR	0.003 J	0.0076 U	34.6104	0.2063	0.0100 U	NR	0.0229
		02/26/88(1)	0.370 U	30.000	0.004 J	0.00764	060.7991	0.3238	0.0100 U	NR	0.0200 U
		04/19/88(2)	0.0388	20.000	0.004 J	0.076 U	60.9966	0.3460	0.0100 U	NR	0.1214

Phase II RFI/RI Work Plan (Subtask) - 903 Pad, Mound, and East Tranche Areas, Draft Final
Rocky Flats Plant, Golden, Colorado, January 24, 1991
22578E/RI/28C 01-85-91/RPT/2

TABLE 2-8C

**SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED
GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Nickel-Zinc)
(Concluded)**

Well Designation	Lithology of Screened Interval ^{a)}	Sample Date ^{b)}	Nickel (Ni), disc. mg/l	Potassium (K), disc. mg/l	Selenium (Se), disc. mg/l	Silver (Ag), disc. mg/l	Sodium (Na), disc. mg/l	Strontium (Sr), disc. mg/l	Thallium (Tl), disc. mg/l	Tin (Sn), disc. mg/l	Zinc (Zn), disc. mg/l
LOWER HSU											
		07/22/88(3)	0.0370 U	15.000	0.005 U	0.0076 U	69.9706	0.4038	0.0100 U	NR	0.0200 U
		01/23/89(1)	0.0220 U V	11.900 V	0.0013 U A	0.0040 U V	79.4000 V	0.4850 V	0.0010 U V	NR	0.0127 U A
		06/13/89(3)	0.0400 U A	10.000 A	0.0050 U A	0.0100 U A	78.7000 V	1.0000 U V	0.0100 U A	0.1000 U V	0.0298 A
		07/27/89(3)	0.0220 U	NR	NR	0.0040 U	74.5441	0.4486	NR	NR	0.0080 U
		08/17/89(3)	0.0400 U R	7.690 A	0.0050 U V	0.0100 U V	75.6000 V	1.0000 U V	0.0010 U A	0.1000 U V	0.0200 U R
		08/18/89(3)	0.0400 U R	7.690 A	0.0050 U V	0.0100 U V	75.6000 V	1.0000 U V	0.0010 U A	0.100 U V	0.0200 U R
		10/20/89(4)	0.0200 U	6.030	0.0020 U	0.0300 U	73.9000	0.4440	0.0030 U	1.0000 U	0.0413
		10/20/89(4)	0.0200 U	6.780	0.0020 U	0.0300 U	72.7000	0.4560	0.0030 U	1.0000 U	0.0159

^{a)} SS#1 = Arapahoe Formation Sandstone #1; CS = Arapahoe Formation claystone/siltstone; AL = alluvium; HSU = Hydrostratigraphic Unit
^{b)} Number in parenthesis = the calendar quarter sample was collected.

Notes:

- (1) VALUE QUALIFIERS: NR = Analyte not reported; U = Analyzed but not detected; * = Holding time not met; E = Estimated value; J = Present below detection limit; B = Present in laboratory blank; N = Batch spike not in 80-120% range
- (2) DATA VALIDATION QUALIFIERS: (No validation qualifier indicates data has not been validated); R = Rejected; A = Acceptable with qualifications; V = Valid
- (3) Wells in upper HSU have portion of well screen or entire well screen below boundary between "alluvial" and "bedrock" components of RFI/RI shown in Figure 1-1.
- (4) Wells in lower HSU have entire well screen below boundary between "alluvial" and "bedrock" components of RFI/RI shown in Figure 1-1.
- (5) Wells 1487BR is in lower HSU according to Note (4) above; however, it is screened in weathered SS#5 that subcrops and may be hydrologically connected to upper HSU.

Within Operable Unit 2, samples from wells in the East Trenches Area had the highest reported values for iron, lithium, molybdenum, and manganese.

2.2.3.4 Major Ions

Background data (Table 2-9) indicate that the lower sandstones have higher concentrations of sulfates, chloride and TDS than were found in groundwater in the upper HSU. The data from the monitoring wells screened in the bedrock in Operable Unit 2 generally show the reverse of this trend. Major ions tend to be more elevated in shallow wells than in deeper wells. The significance of this trend will be more fully explored during this Phase II RFI/RI.

2.2.4 Bedrock

Analytical chemistry testing was conducted on samples of the bedrock collected during the Phase I RI. Data reported here are from boreholes drilled into the bedrock with samples collected at or below the alluvial/bedrock interface. Borehole summary information is shown in Table 2-1.

The majority of metal concentrations in bedrock samples were below either the reported background (Rockwell International 1989e) for those formations or at the analytical method detection limits. A single sample from BH2587 contained 20 mg/kg arsenic above the background level of 15 mg/kg. No radionuclide values reported for these samples were above the background levels.

The only borehole with volatile organic compounds reported at or below the alluvial/bedrock interface was BH 2587 located at the 903 Pad Area, Trench T-2 Site (IHSS 109) (Table 2-10). The sample collected at the 19.7-20.5 foot interval contained toluene, methylene chloride, acetone, TCE, PCE, 2-butanone and 1,1,1-trichloroethane (TCA). The depths above the 19.7-20.5-ft interval also showed higher concentration of these compounds as well as ethyl benzene, 4-methyl 2-pentanone, xylene, and chloroform. The alluvium/bedrock contact was at depth 14.8 feet in this borehole.

Low levels of methylene chloride, acetone, and chloroform were found in numerous samples from many boreholes. However, these compounds are common laboratory contaminants. These compounds are also frequently found in laboratory blanks.

Semi-volatile organic compounds were observed in a number of boreholes (Table 2-11). While most phthalate compounds are laboratory contaminants, one borehole (BH 3387), had a validated concentration of 240 ppb, which is high for laboratory contamination. This borehole is located near the Mound Oil Burn Pit and trench T-1 sites.

TABLE 2-9

**SUMMARY OF NON-METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED
IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs**

Well Designation	Lithology of Screened Interval ^a	Sample Date ^b	Chloride	Cyanide	Fluoride	Sulfate	Nitrate (NO ₃)	Nitrate - Nitrite as N	TDS	Bicarbonate
UPPER HSU										
1587	AL	10/08/87 (4)	56.7	NR	NR	15.5	40.2857	9.1	487.0	261.0
		03/01/88 (1)	58.8	NR	NR	24.6	17.1768	3.88	456.0	138.0
		04/21/88 (2)	48.1	NR	NR	25.8	21.3381	4.82	437.0	244.0
		08/03/89 (3)	23.5	NR	NR	12.7	NR	3.73	354.0	233.0
		12/04/89 (4)	NR	0.0100U	NR	NR	NR	NR	NR	NR
4086	CS	05/06/87 (2)	19.9	1.0U	NR	470.0	6.1978	1.40	1011.0	205.0
		06/01/87 (2)	14.9	1.0U	NR	390.0	NR	NR	NR	NR
		10/26/87 (4)	8.79	NR	NR	218.0	29.3067	6.62	679.0	255.0
		03/11/88 (1)	7.56	NR	NR	131.0	16.6898	3.77	598.0	180.0
		05/12/88 (2)	7.24	NR	NR	135.0	16.8226	3.80	576.0	293.0
		02/01/90 (1)	10.0	NR	0.6	120.0	NR	2.40	560.0	400.0
6286	SS#3	04/09/87 (2)	28.0	1.0	NR	60.0	10.1821	2.30	274.0	67.5
		04/29/87 (2)	26.9	1.0U	NR	90.0	11.5102	2.60	286.0	124.0
		05/26/87 (2)	25.5	1.0U	NR	48.0	15.0518	3.40	295.0	164.0
		07/07/87 (3)	102.0	1.0U	NR	23.0	10.1821	2.30	280.0	157.0
		02/18/88 (1)	29.7	NR	NR	39.0	7.0832	1.60	275.0	172.0
		04/14/88 (2)	26.8	NR	NR	57.7	12.7940	2.89	302.0	134.0
		07/15/88 (3)	30.2	NR	NR	57.6	13.2367	2.99	283.0	151.0
		10/20/88 (4)	71.0A	NR	NR	54.1A	32.8041	7.41A	328.0A	164.0A

TABLE 2-9

**SUMMARY OF NON-METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED
IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Continued)**

Well Designation	Lithology of Screened Interval (a)	Sample Date (b)	Chloride	Cyanide	Fluoride	Sulfate	Nitrate (NO ₃)	Nitrate - Nitrite as N		TDS	Bicarbonate
UPPER HSU											
1287BR	CS	01/23/89 (1)	28.2 V	NR	NR	53.9 V	NR	2.46 V		288.0 A	132.0 V
		07/20/89 (3)	31.6	NR	NR	64.0	NR	2.79		309.0	140.0
		02/16/90 (1)	35.0	NR	1.0	45.0	NR	3.5		320.0	180.0
		02/26/88 (1)	38.8	NR	NR	46.2	3.1432	0.71		617.0	212.0
		04/21/88 (2)	57.0	NR	NR	102.0	5.8879	1.33		641.0	354.0
2387BR	SS#1	07/26/88 (3)	53.3	NR	NR	203.0	7.0832	1.60		635.0 JA	348 JA
		01/24/90 (1)	37.0	NR	2.5	92.0	NR	2.20		540	400
		10/22/87 (4)	55.9	NR	NR	27.0	12.2628	2.77		414.0	243.0
		03/03/88 (1)	62.8	NR	NR	17.1	12.4841	2.82		431.0	146.0
		04/29/88 (2)	64.0	NR	NR	17.5	11.9529	2.70		392.0	242.0
2587BR	SS#1	08/12/88 (3)	49.0 JA	NR	NR	18.1 JA	12.1742	2.75 JA		446.0 R	261.0 JA
		11/04/88 (4)	65.1 V	NR	NR	16.6 A	13.1925	2.98 V		344.0 A	192.0 A
		02/07/89 (1)	65.8 V	NR	NR	18.4 V	NR	2.31 V		459.0 A	237.0 A
		12/04/89 (4)	NR	0.0100 U	NR	NR	NR	NR		NR	NR
		02/20/90 (1)	73	NR	0.7	19	NR	4.3		440	310
		02/20/90 (D)	72	NR	0.5 U	18	NR	4.4		470	310
		10/22/87 (4)	36.0	NR	NR	35.5	34.0436	7.69		448.0	250.0
		03/04/88 (1)	37.3	NR	NR	32.5	34.0436	7.69		466.0	152.0
	05/12/88 (2)	34.8	NR	NR	28.5	30.5463	6.90		496.0	235.0	

TABLE 2-9

**SUMMARY OF NON-METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED
IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs**
(Continued)

Well Designation	Lithology of Screened Interval (a)	Sample Date ^(b)	Chloride	Cyanide	Fluoride	Sulfate	Nitrate (NO ₃)	Nitrate - Nitrite as N	TDS	Bicarbonate
3687BR	SS#1/CS	08/16/88 (3)	34.6JA	NR	NR	32.4R	34.0436	7.69JA	457.0	267.0JA
		02/15/89 (1)	39.1A	NR	NR	28.1V	NR	7.31V	475.0A	248.0A
		01/01/90 (1)	37.0	NR	0.6	230.0	NR	0.66	670.0	360.0
		11/06/87 (4)	218.0	NR	NR	43.5	20.2314	4.57	375.0	218.0
		03/10/88 (1)	29.6	NR	NR	34.4	21.1611	4.78	395.0	133.0
		05/05/88 (2)	29.9	NR	NR	33.0	19.4788	4.40	405.0	212.0
		08/19/88 (3)	34.2JA	NR	NR	40.5JA	18.2392	4.12JA	431.0JA	240.0JA
		02/15/89 (1)	41.9A	NR	NR	27.7V	NR	8.06V	444.0A	242.0A
		03/05/90 (1)	48.0	NR	0.5U	30.0	NR	6.1	540.0	350.0
3486	SS#3	03/17/87 (1)	65.9	1.0U	NR	800	0.8854U	0.20U	1789	372
		04/06/87 (2)	53.5	1.0U	NR	40.0	0.8854U	0.20U	1772	357
		06/02/87 (2)	54.0	1.0U	NR	940	0.8854U	0.20U	1761	333
		07/28/87 (3)	54.4	1.0U	NR	990	0.8854U	0.20U	1813	319
		03/03/88 (1)	59.6	NR	NR	763	0.0885U	0.02U	1700	111
		05/03/88 (2)	58.3	NR	NR	725	0.0885U	0.02U	1760	239
		11/04/88 (4)	56.2V	NR	NR	1084A	0.0885U	0.02UV	1750A	316A
		02/09/89 (1)	0.0167	NR	NR	1058V	NR	0.02UV	1886A	306A

TABLE 2-9

**SUMMARY OF NON-METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED
IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Continued)**

Well Designation	Lithology of Screened Interval ^(a)	Sample Date ^(b)	LOWER HSU						Nitrate - Nitrite as N	TDS	Bicarbonate
			Chloride	Cyanide	Fluoride	Sulfate	Nitrate (NO ₃)				
1487BR	SS#5	9/1/87 (3)	27.0	1.0	NR	27.0	7.5259	1.70	661	530	
		10/13/87 (4)	30.2	NR	NR	41.0	7.0832	1.60	635	48	
		3/1/88 (1)	28.0	NR	NR	43.1	7.0389	1.59	265	36.3	
		4/22/88 (2)	24.8	NR	NR	48.8	7.5259	1.70	275	75.4	
		8/9/88 (3)	26.1JA	NR	NR	41.9R	7.5702	1.71JA	287JA	112JA	
		1/25/89 (1)	32.6V	NR	NR	46.5VU	NR	1.83A	320A	158A	
		1/25/89 (D)	32.7V	NR	NR	47.0VU	NR	1.74A	308A	155A	
		8/3/89 (3)	34.0	NR	NR	47.8	NR	2.12	326	177	
		1/25/90 (1)	46.0	NR	0.9	60.0	NR	2.6	420	290	
1687BR	SS#3	1/25/90 (D)	46.0	NR	0.9	50.0	NR	2.7	430	310	
		10/17/87 (4)	3.7	NR	NR	77.0	6.9947	1.58	264.0	133.0	
		03/01/88 (1)	7.46	NR	NR	93.8	1.5494	0.35	282.0	83.1	
		04/22/88 (2)	4.04	NR	NR	84.8	0.2213	0.05	277.0	166.0	
		08/10/88 (3)	3.33JA	NR	NR	64.6R	0.0885U	0.02UA	286.0JA	176.0JA	
		02/07/89 (1)	3.34V	NR	NR	77.0V	NR	1.56V	312.0A	171.0A	
		08/03/89 (3)	3.57	NR	NR	85.4	NR	1.89	337.0	185.0	
		03/17/90 (1)	10.0	NR	0.6	62.0	NR	2.5	340.0	220.0	
		03/08/88 (1)	5.85	NR	NR	28.9	0.0885U	0.02U	163.0	41.4	
1887BR	SS#4	11/04/89 (4)	23 V	NR	NR	59.0V	NR	6.2 V	340.0A	360 A	

TABLE 2-9

**SUMMARY OF NON-METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED
IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Continued)**

Well Designation	Lithology of Screened Interval ^(a)	Sample Date ^(b)	Chloride	Cyanide	Fluoride	Sulfate	Nitrate (NO ₃)	Nitrate - Nitrite as N	TDS	Bicarbonate
LOWER HSU										
2087BR	SS#3	12/13/89 (4)	8.0	NR	NR	100.0	NR	NR	500.0	228.0
		02/09/90 (1)	NR	NR	NR	NR	NR	3.3	NR	NR
2287BR	CS	3/8/88 (1)	8.22	NR	NR	121	0.0885U	0.02U	465	54
		5/3/88 (2)	5.70	NR	NR	230	0.1771	0.04	480	99
		8/12/88 (3)	6.56JA	NR	NR	337JA	0.1771	0.04JA	586R	119JA
		11/9/89 (4)	7.84V	NR	NR	387A	0.4870	0.11V	638A	97A
		2/9/89 (1)	9.27V	NR	NR	458V	NR	0.14V	759A	105A
		2/8/90 (1)	16	NR	0.5	370	NR	0.06	870	190
2887BR	CS	03/15/88 (1)	6.27	NR	NR	32.0	0.3984	0.09	137.0	38.1
		05/12/88 (2)	23.4	NR	NR	130.0	0.1771	0.04	516.0	93.6
		02/20/89 (1)	77.9A	NR	NR	195.0V	NR	0.04V	529.0A	114.0A
		03/14/90 (1)	NR	NR	NR	NR	NR	3.8	NR	NR
3087BR	CS	01/22/88 (1)	40.1	NR	NR	22.2	0.0885U	0.02U	118	87
		03/03/88 (1)	114	NR	NR	16.1	0.0885U	0.02U	376	84
		04/22/88 (2)	125	NR	NR	16.5	0.1771	0.04	412	157
		08/09/90 (3)	124JA	NR	NR	2.82R	0.0885U	0.02UA	419JA	169JA
		08/09/90 (D)	127JA	NR	NR	2.78R	0.0885U	0.02UA	419JA	180JA
		02/01/89 (1)	132A	NR	NR	2.91V	NR	0.02UV	419A	156A

TABLE 2-9

**SUMMARY OF NON-METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED
IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Continued)**

Well Designation	Lithology of Screened Interval (a)	Sample Date ^(b)	Chloride	Cyanide	Fluoride	Sulfate	Nitrate (NO ₃)	Nitrate - Nitrite as N	TDS	Bicarbonate
LOWER HSU										
3187	SS#3	10/29/87 (4)	10.3	NR	NR	125	0.8854U	0.20U	346	60.8
		5/12/88 (2)	9.01	NR	NR	115	0.7526	0.17	312	67.6
		8/25/88 (3)	9.071A	NR	NR	113 JA	15.7158	3.55V	308 JA	94.1 JA
		2/22/89 (1)	9.79 A	NR	NR	118 V	NR	0.05 V	307 A	74.6 A
		3/13/90 (1)	12	NR	1.0	120	NR	0.05	410	130
3487BR	CS	03/10/88 (1)	5.37	NR	NR	114.0	0.7526	0.17	288.0	61.4
		05/12/88 (2)	3.94	NR	NR	97.0	0.2656	0.06	314.0	125.0
		05/12/88 (D)	4.58	NR	NR	100.0	0.2213	0.05	319.0	127.0
		02/20/89 (1)	7.25 A	NR	NR	80.6 V	NR	0.14V	381 A	142.0 A
		11/23/87 (4)	6.38	NR	NR	73.6	0.0885U	0.02 U	327.0	111.0
4587BR	SS#5	02/26/88 (1)	8.33	NR	NR	55.0	0.0885U	0.02 U	342.0	114.0
		04/19/88 (2)	10.6	NR	NR	104.0	0.2213	0.05	344.0	119.0
		07/22/88 (3)	11.0	NR	NR	47.0	0.3099	0.07	341.0	232.0
		01/23/89 (1)	13.9V	NR	NR	50.5 V	NR	0.02 UV	376.0 A	233.0V
		07/27/89 (3)	15.2	NR	NR	54.3	NR	.02 U	388.0	263.0
		03/15/90 (1)	21.0	NR	0.7	59.0	NR	0.05 U	410.0	350.0

TABLE 2-9

**SUMMARY OF NON-METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED
IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Concluded)**

(a) SS#1 = Arapahoe Formation Sandstone #1; CS = Arapahoe Formation Claystone/Siltstone; AI = Alluvium
(b) Number in parenthesis = the calendar quarter sample was collected.

NOTES:

- (1) **VALUE QUALIFIERS:** NR = Analyte not reported U = Analyzed but not detected * = Holding time not met E = Estimated value
J = Present below detection limit B = Present in laboratory blank N = Batch spike not in 80-120% range
- (2) **DATA VALIDATION QUALIFIERS:** (No validation qualifier indicates data has not been validated.) R = Rejected; A = Acceptable with qualifications; V = Valid
- (3) Wells in upper HSU have portion of well screen or entire well screen in upper HSU.
- (4) Wells in lower HSU have entire well screen below boundary between "alluvial" and "bedrock" components of RFI/RI shown in Figure 1-1.
- (5) Well 1487BR is in lower HSU according to Note (4) above; however, it is screened in weathered SS#5 that subcrops and may be hydrologically connected to upper HSU.
- (6) Nitrate calculated from measured concentration of Nitrate-Nitrite as N.

SUMMARY OF VOLATILEORGANIC COMPOUNDS DETECTED IN BEDROCK SAMPLES FROM BOREHOLES

[illegible]

TABLE 2-10

**SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN
BEDROCK SAMPLES FROM BOREHOLES
(Continued)**

Borehole Designation	Sample Depth	Lithology ^{a)}	Analytical Data Available ^{b)}	Volatile Organic Compound Concentrations (µg/kg) ^{b)}												Total Xylenes	Chloro- form
				Ethyl Benzene	4-methyl 2- pentanone	Toluene	Methylene Chloride	Acetone	Carbon Di- sulfide	Carbon Tetra- chloride	Trichloro- ethylene	cis 1,3- dichloro- propene	Tetra- chloro- ethylene	1,2- Dichloro- propene	2- Butanone	Chloro- ethane	1,1,1, Trichloro- ethane
3487	17.0-18.0	SS#1	YN														
	21.0-22.1	SS#1	YN														
3687	23.4-24.5	CS	Y				83	64									
3787	18.0-21.7	SS#1	Y				121B	130B									
	25.0-26.2	CS	Y				171B	150B									
3987	14.5-17.0	SS#1	Y					170							72		
	17.0-19.5	SS#1	Y					120							58		
	19.5-22.0	SS#1	Y					140							55		
4087	7.0-9.3	AL/ CS	Y					120									
	9.5-12.0	CS	Y					150									
4187	14.5-17.0	AL/ CS	Y					210									
	17.0-19.5	CS	Y					150			34						71
4287	22-24.5	PL/ SS#1	Y														
	24.5-27	SS#1	Y														
	27-29.5	SS#1	Y														
	29.5-32	SS#1	Y														
	32-34.5	SS#1	Y					140									
	34.5-35.9	SS#1	Y					68			111						61
	37-39.5	SS#1	Y					62									

TABLE 2-10

**SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN
BEDROCK SAMPLES FROM BOREHOLES
(Continued)**

Borehole Designation	Sample Depth	Lithology ^(a)	Analytical Data Available ^(a)	Volatile Organic Compound Concentrations (µg/kg) ^(a)														
				Ethyl Benzene	4-methyl 2-pentanone	Toluene	Methylene Chloride	Acetone	Carbon Disulfide	Carbon Tetra- chloride	Trichloro- ethylene	cis 1,3- dichloro- propene	Tetra- chloro- ethylene	1,2- Dichloro- propene	2- Butanone	Chloro- ethane	1,1,1, Trichloro- ethane	Total Xylenes	Chloro- form
4387	39.5-40.4	SS#1	Y					120										
	45.5-47	SS#1	Y					78										
	27.2-29.7	CS	YN															
	29.7-32.0	CS	YN															
4487	29.5-32	SS#1	Y				100	140B										
	32-34.5	SS#1 /CS	Y				250	180B										
4587	20-22.3	SS#1	YN															
	22.5-25	SS#1	YN															
	32.5-33.9	SS#1	YN															
	35-37.5	SS#1	YN															
4687	27-29.5	CS	Y					170B										
	29.5-32	CS	Y				70	270B										
4787	26.2-27.2	CS	Y			210	120B	480B									100	
	27.2-28.2	CS	Y				60B	770B									38	
4887	13.2- 15.11	CS	YN															
	15.2-16.7	CS	YN															
4987	22-24	CS	Y				70B	90B									150	

TABLE 2-10

**SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN
BEDROCK SAMPLES FROM BOREHOLES
(Continued)**

Borehole Designation	Sample Depth	Lithology ^(a)	Analytical Data Available ^(b)	Volatile Organic Compound Concentrations (µg/kg) ^(c)									
				Carbon Disulfide	Carbon Tetrachloride	Trichloroethylene	cis 1,3-dichloropropene	Tetrachloroethylene	1,2-Dichloropropene	2-Butanone	Chloroethane	1,1,1-Trichloroethane	Total Xylenes
5087	12.0-12.9	CS	Y										
	14.5-17	CS	Y						110				
	17-19.5	CS	Y						98				

^(a) AL = Alluvial; SS#1 = Arapahoe Formation, sandstone lithologic unit #1; CS = Arapahoe formation claystone/siltstone.

^(b) Y = yes as follows; YN - yes, but no data above detection limits.

^(c) None of the available data has been validated; J = present below detection limit; B = present in laboratory blank.

TABLE 2-11

**SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUNDS DETECTED
IN SOIL SAMPLES FROM BOREHOLES DRILLED INTO BEDROCK**

Borehole Designation	Sample Depth	Lithology ^(a)	Analytical Data Available ^(b)	Semi-Volatile Organic Compound ($\mu\text{g}/\text{kg}$) ^(c)				bis (2-ethylhexyl) phthalate
				N-Nitrosodi- phenylamine	di-n-butyl phthalate	di-n-octyl phthalate		
2287	22.2 - 23.4	CS	Y	89J				1600
2387	11.2 - 11.9	CS	Y					2700
2487	10.0 - 10.9	CS	Y					2600B
2587	18.5 - 19.3	CS	Y			56J		930B
	19.7 - 20.5	CS	Y					870B
2787	13.0 - 14.4	CS	Y					220J
2887	11.0 - 12.0	CS	Y					2100
3187	15.7 - 22.9	CS	Y	40J				580
3287	17.2 - 18.0	CS	Y					9J
3387	7.8 - 14.7	AL/SS#1/CS	Y	41J				
	14.7 - 15.9	CS	Y	37J				
	18.9 - 19.8	CS	Y	42J				240V
	19.5 - 20.8	CS	Y	49J				450
3487	17.0 - 18.0	SS#1	Y	33J				
	21.0 - 22.1	SS#1	Y				35J	220J
3687	23.4 - 24.5	CS	Y				38J	360
3787	18.0 - 21.7	SS#1	Y					550
	25.0 - 26.2	CS	Y				41J	420

TABLE 2-11

**SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUNDS DETECTED
IN SOIL SAMPLES FROM BOREHOLES DRILLED INTO BEDROCK
(Continued)**

Borehole Designation	Sample Depth	Lithology ^(a)	Analytical Data Available ^(b)	Semi-Volatile Organic Compound ($\mu\text{g}/\text{kg}$) ^(c)		
				N-Nitrosodi- phenylamine	di-n-butyl phthalate	di-n-octyl phthalate
3987	14.5 - 17.0	SS#1	Y			bis (2-ethylhexyl) phthalate
	17.0 - 19.5	SS#1	YN			250V
	19.5 - 22.0	SS#1	YN			
4087	7.0 - 9.3	AL/CS	Y			160J
	9.5 - 12.0	CS	Y			200J
4187	14.5 - 17.0	AL/CS	Y			150J
	17.0 - 19.5	CS	Y			190J
4287	22.0 - 24.5	AL/SS#1	Y		170J	500
	24.5 - 27.0	SS#1			39J	520
	27.0 - 29.5					480
	29.5 - 32.0				34J	720
	32.0 - 34.5					640
	34.5 - 35.9			100J	34J	410
	37.0 - 39.5					520
	39.5 - 40.4				34J	610
	45.5 - 47.0					160V
4387	27.2 - 29.7	CS	Y	37JB		310JB

TABLE 2-11

**SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUNDS DETECTED
IN SOIL SAMPLES FROM BOREHOLES DRILLED INTO BEDROCK
(Continued)**

Borehole Designation	Sample Depth	Lithology ^(a)	Analytical Data Available ^(b)	Semi-Volatile Organic Compound ($\mu\text{g}/\text{kg}$) ^(c)			
				N-Nitrosodi- phenylamine	di-n-butyl phthalate	di-n-octyl phthalate	bis (2-ethylhexyl) phthalate
4487	29.7 - 32.0	CS	Y		34JB		730JB
	24.5 - 27.0	SS#1	Y		38JB		
	29.5 - 32.0	SS#1	Y		38JB		
	32.0 - 34.5	SS#1/CS	Y		38JB		
4587	20.0 - 22.3	SS#1	Y				180J
	22.5 - 25.0		Y				120J
	25.0 - 27.5		Y				190J
	27.5 - 30.0		Y				130J
	30.0 - 32.5		Y				150J
	32.5 - 33.9		Y				220J
	35.0 - 37.5		Y				140J
			Y				230J
4687	27.0 - 29.5	CS	Y				350
4787	29.5 - 32.0	CS	Y				960B
	26.2 - 27.2	CS	Y		44JB		1100B
4887	27.2 - 28.2	CS	Y		44JB		478B
	13.2 - 15.1	CS	Y		42JB		560B
4987	15.2 - 16.7	CS	Y		35JB		
	20.0 - 22.0	CS	Y				710B

TABLE 2-11

**SUMMARY OF SEMI-VOLATILE ORGANIC COMPOUNDS DETECTED
IN SOIL SAMPLES FROM BOREHOLES DRILLED INTO BEDROCK
(Continued)**

Borehole Designation	Sample Depth	Lithology ^(a)	Analytical Data Available ^(b)	Semi-Volatile Organic Compound ($\mu\text{g}/\text{kg}$) ^(c)			
				N-Nitrosodi- phenylamine	di-n-butyl phthalate	di-n-octyl phthalate	bis (2-ethylhexyl) phthalate
5087	22.0 - 24.0	CS	Y				720B
	24.1 - 25.6	CS	Y				580B
	12.0 - 12.9	CS	Y		36JB		450B
	14.5 - 17.0	CS	Y		55JB		690B
	17.0 - 19.5	CS	Y		35JB		370B

^(a) AL = Alluvial, SS#1 = Arapahoe Formation, sandstone lithologic unit #1, CS = Arapahoe formation/claystone/siltstone.

^(b) Y = yes as follows; YN = yes, but no data above detection limits.

^(c) VALUE QUALIFIERS J = present below detection limit, B = present in laboratory blank.

DATA VALIDATION QUALIFIERS: V = Valid

There is not adequate information from existing soil data to determine if the deeper bedrock is contaminated with organic compounds.

2.3 CONCEPTUAL MODEL

A site conceptual model was developed to illustrate how contamination may be dispersed to the environment via potential pathways identified in the Phase I RI report and during Phase II RFI/RI planning. The conceptual model is shown graphically in Figure 2-24. The interrelationships between the upper and lower hydrostratigraphic units (HSUs), and between Operable Unit 2 and adjacent operable units are depicted in this figure.

This conceptual model was used to assist in identifying sampling needs and will be further used for the baseline risk assessment. Additional data will be obtained to refine risk assessment calculations and to conduct the Feasibility Study (FS).

2.3.1 Bedrock Contamination Sources

Potential sources of contamination in bedrock have been divided into 3 general categories: (1) plumes of dissolved (aqueous phase) contaminants in the upper HSU, (2) pools or pockets of non-aqueous phase liquid contaminants near the bottom of the upper HSU, and (3) unidentified off-site sources located topographically and/or hydraulically upgradient of the site.

At present, the primary contaminants identified in the bedrock are aqueous-phase trichloroethylene (TCE) and tetrachloroethylene (PCE). Plumes of these volatile organic contaminants and carbon tetrachloride (CCl_4) dissolved in groundwater were identified in the upper HSU during the Phase I RI. Other volatile and semivolatile organics and inorganics have also been identified in the upper HSU, but, for the most part, have not been identified in the bedrock. The three primary volatile organic contaminants are all able to exist as dense non-aqueous phase liquids at concentrations above their concentration of saturation in water. In the unlikely event they are present on site, pools of dense non-aqueous phase liquids could accumulate in depressions at the bottom of the upper HSU. However, of the many monitoring wells and boreholes that have been drilled at Rocky Flats, there have never been reports of non-aqueous phase liquids found in wells.

It is not known if there are potential sources of bedrock contamination that are located upgradient of Operable Unit 2. The bedrock beneath Operable Unit 1 (881 Hillside) has not been characterized sufficiently to determine whether or not it is a potential source of contamination that may contribute to the bedrock system in Operable Unit 2.

2.3.2 Release Mechanisms

There is a potential for contaminants in the upper HSU to have impacted the bedrock system. There are six pre-1986 monitoring wells that have been identified in Operable Unit 2. These wells (Well Nos. 171, 271, 174, 374, 774, and 2274) were constructed in 1971 and 1974. Design details of these wells are not available other than estimates of total depth. The first five of these six wells range from approximately 24 to 50 feet in depth. However, Well 2274 is 162 feet deep and may penetrate lower sandstone layers. These wells represent potential release mechanisms from the upper HSU to lower HSU(s), either by long screened intervals or ineffective seals.

Contaminated groundwater in the upper HSU may also potentially enter lower sandstones where they subcrop beneath the colluvium on the valley side slopes (see Figure 2-24). This may be the situation at Well 1487BR. Another potential mechanism of release into bedrock is by percolation through fractures in the weathered and unweathered claystone bedrock downward to a lower sandstone layer, if such fractures exist. This release mechanism is judged to have a low probability at this time as a result of the low hydraulic conductivity values reported in the unweathered claystone units.

2.3.3 Potential Exposure Pathways

The primary potential pathways for migration of contaminants through groundwater flow in bedrock to potential receptors are by seepage to surface waters, pumping from water supply wells that tap the affected groundwater downgradient of the site, and contamination of surface water by the interaction of surface water and groundwater. Secondary potential exposure pathways may occur through wind dispersal of contaminated dust or soil gas resulting from the seepage of contaminated groundwater and subsequent drying at outcrop areas.

2.3.4 Receptors

There may be different potential receptor populations exposed via each of the potential exposure pathways described above. For each pathway, there are three potential intake routes: ingestion, inhalation, and dermal contact. Potential receptors of groundwater contamination are human. Biota may be present at, downgradient or downwind of seep locations.

2.3.5 Summary

The elements of the site conceptual model described above are shown in Figure 2-24. This figure depicts the potential sources of contamination, mechanisms of contaminant release, exposure pathways, and primary receptors. The model as pictured is based on an evaluation of available Phase I RFI/RI data and postulated exposure pathways not yet proven. As additional information is obtained, the overall model and specific

portions of the model (for example, the confined groundwater flow regime) may be refined or expanded to address risk assessment issues.

The Baseline Risk Assessment for both upper and lower HSUs will be combined for the RI Report. The Phase II RFI/RI Alluvial Work Plan describes how this is to be done.

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section provides a preliminary identification of chemical-specific applicable or relevant and appropriate requirements (ARARs) for weathered bedrock groundwater at Operable Unit 2 so that appropriate analytical detection limits are used during the RFI/RI (RI) to evaluate compliance with these ARARs. The CMS/FS (FS) report will fully address chemical-specific ARARs as well as action- and location-specific ARARs in the development and evaluation of remedial alternatives.

3.1 THE ARAR BASIS

The basis for ARARs is cited in Section 121(d) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), which requires that Fund-financed, enforcement, and federal facility remedial actions comply with applicable or relevant and appropriate federal laws or promulgated state laws, whichever is more stringent. For the purposes of identification and notification of promulgated state standards, the term "promulgated" means that the standards are of general applicability and are legally enforceable (NCP, 40 CFR 300.400(g)(4)).

Health-based, chemical-specific ARARs pertinent to ground-water quality have been identified for the EPA Contract Laboratory Program (CLP) Toxic Compound List (TCL) organic and Toxic Analyte List (TAL) inorganic compounds, as well as radionuclides and conventional pollutants that were detected. The chemical-specific ARARs are derived primarily from federal and state health and environmental statutes and regulations. As discussed below, in some instances these standards are classified as items "to be considered" (TBC). A summary of chemical-specific ARARs for the contaminants found at the 903 Pad, Mound and East Trenches areas is presented in Table 3-1.

This work plan describes only the investigative requirements relative to bedrock groundwater in Operable Unit 2. The parameters for which proposed ARARs are identified within this work are compiled from maximum concentrations above detection limits in bedrock groundwater wells within Operable Unit 2. However, the same application of ARARs pertain to both the upper and lower hydrostratigraphic units (alluvial and bedrock groundwater) due to the potential cross-connection of the two units. A common list of parameters will be analyzed for both hydrostratigraphic units (see Section 8.0, Field Sampling Plan).

TABLE 3-1

**PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS
DETECTED IN BEDROCK GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES**

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water ($\mu\text{g}/\text{l}$) ¹	Well Designation # & Sample Date	Detection Limit ($\mu\text{g}/\text{l}$)	Proposed ARAR ($\mu\text{g}/\text{l}$)	Proposed TBC ($\mu\text{g}/\text{l}$)	Reference	Comment
<u>Organic Compounds</u>							
Acetone	27B	2887BR (12/14/89) and (12/06/89)	10		10U	Acetone is RCRA (40 CFR Part 264 Subpart F) Appendix IX constituent (Background is TBC).	
Methylene Chloride	12	4587BR (02/25/88)	5		5U	RCRA (40 CFR Part 264.94) Subpart F (Background is TBC).	
Tetrachloroethylene	140	2087BR (08/09/89)	5		10	WQCC Ground Water Standard; Interim Organic Pollutant Standard is TBC.	
Toluene	5AB	1887BR (01/03/89)	5		2420	WQCC Ground Water Standard; Interim Organic Pollutant Standard is TBC.	Maximum detected concentration is below proposed standard.
Trichloroethylene	120V	1487BR ² (01/25/89)	5		5U	SWDA MCL (40 CFR 141.61[a]).	
Carbon Disulfide	5	4587BR (08/17/89)	5	5		RCRA (40 CFR Part 264.94) Subpart F (Background is TBC).	
Chloroform	36V	1887BR (03/07/88) and 1487BR ² (11/28/89)	5	100		SDWA MCL (40 CFR 141.12).	Standard is for total trihalomethanes. Maximum detected concentration is below proposed standard.
Carbon Tetrachloride	450	1487BR ² (11/28/89)	5	5		SDWA MCL (40 CFR 141.61[a]).	

TABLE 3-1

**PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS
DETECTED IN BEDROCK GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES**
(Continued)

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (mg/L) ¹	Well Designation # & Sample Date	Detection Limit (mg/L)	Proposed ARAR (mg/L)	Proposed TBC (mg/L)	Reference	Comment
<u>Dissolved Metals</u>							
Aluminum	1.1972	1487BR ³ (10/13/87)	0.20		5.0	WQCC Ground Water Standard; Table 3, Agricultural Standard is TBC.	Maximum detected concen- tration is below proposed standard.
Antimony	0.0728	3486 (11/04/88)	0.06		0.06U	RCRA (40 CFR Part 264.94) Subpart F (Background is TBC).	Maximum detected concen- tration is below proposed standard.
Arsenic	0.040	3087BR (01/22/88)	0.01	0.05		SDWA MCL (40CFR 141.11[b])	Maximum detected concen- tration is below proposed standard.
Barium	0.7860	1687BR (03/01/88)	0.20	1.0		SDWA MCL (40 CFR 141.11 [b]).	Maximum detected concen- tration is below proposed standard.
Beryllium	0.0022J	3087BR (02/01/89)	0.005		0.1	WQCC Ground Water Standard; Table 3, Agricultural Standard is TBC.	Maximum detected concen- tration is below proposed standard.
Cadmium	0.009A	6286 (06/10/89)	0.005	0.01		SDWA MCL (40 CFR 141.11[b])	Maximum detected concen- tration is below proposed standard.
Calcium	242.3112	3486 (07/28/87)	5	NS		No Standard	
Chromium	0.0453	6286 ³ (10/16/87)	0.01	0.05		SDWA MCL (40 CFR 141.11 [b]).	Analytical results are for total chromium. Maximum detected concentration is below proposed standard.

TABLE 3-1

**PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS
DETECTED IN BEDROCK GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES**
(Continued)

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (mg/l) ¹	Well Designation # & Sample Date	Detection Limit (mg/l)	Proposed ARAR (mg/l)	Proposed TBC (mg/l)	Reference	Comment
<u>Dissolved Metals (cont.)</u>							
Copper	0.0463	2887BR (05/12/88)	0.025		0.2	WQCC Ground Water Standard; Table 3, Agricultural Standard is TBC.	Maximum detected concen- tration is below proposed standard.
Iron	2.1817	3486 (11/04/88)	0.1		0.3	WQCC Ground Water Standard; Table 2, Secondary Drinking Water Standard is TBC.	Analytical results are for soluble iron.
Lead	0.004J	1487BR ³ (10/13/87)	0.005	0.05		SDWA MCL (40 CFR 141.11(b)).	Maximum detected concen- tration is below proposed standard.
Lithium	0.22	3487BR (03/10/88)	0.1		2.5	WQCC Ground Water Standard; Table 3, Agricultural Standard is TBC.	Maximum detected concen- tration is below proposed standard.
Magnesium	92.1996	3486 (05/03/88)	5	NS		No Standard	
Manganese	0.5351	4086 (05/06/87)	0.015		0.05	WQCC Ground Water Standard; Table 2, Secondary Drinking Water Standard is TBC.	Analytical results are for soluble manganese.
Mercury	0.0008	6286 ³ (07/07/87)	0.0002	0.002		SDWA MCL (40 CFR 141.11(b)).	Maximum detected concen- tration is below proposed standard.
Molybdenum	0.1347	2887BR (05/12/88)	0.008	NS		No Standard	

TABLE 3-1

**PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS
DETECTED IN BEDROCK GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES**
(Continued)

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (mg/L) ¹	Well Designation # & Sample Date	Detection Limit (mg/L)	Proposed ARAR (mg/L)	Proposed TBC (mg/L)	Reference	Comment
<u>Dissolved Metals (cont.)</u>							
Nickel	0.1041	6286 ³ (10/16/87)	0.04		0.2	WQCC Ground Water Standard; Table 3, Agricultural Standard is TBC.	Maximum detected concen- tration is below proposed standard.
Potassium	31	1487BR ³ (08/31/87)	5	NS		No Standard	
Selenium	0.071	6286 ³ (04/14/88)	0.005	0.01		SDWA MCL (40 CFR 141.11[b]).	
Silver	0.0291	4086 (03/11/88)	0.01	0.05		SDWA MCL (40 CFR 141.11[b]).	Maximum detected concen- tration is below proposed standard.
Sodium	232.1001	3486 (05/03/88)	5	NS		No Standard	
Strontium	1.4379	1487BR ³ (10/13/87)	0.2	NS		No Standard	Background is 7.12 mg/L.
Zinc	0.1214	4587BR (04/19/88)	0.02		2.0	WQCC Ground Water Standard; Table 3, Agricultural Standard is TBC.	Maximum detected concen- tration is below proposed standard.

TABLE 3-1

**PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS
DETECTED IN BEDROCK GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES**
(Continued)

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (mg/L) ²	Well Designation # & Sample Date	Detection Limit (mg/L)	Proposed ARAR (mg/L)	Proposed TBC (mg/L)	Reference	Comment
<u>Non-Metallic Inorganics</u>							
pH (min)	7.4	4086 (02/19/90)			6.5	WQCC Ground Water Standard; Table 3, Agricultural Standard is TBC.	Minimum pH value is within proposed standard.
pH (max)	8.6	1887BR (11/02/89)			8.5	WQCC Ground Water Standard; Table 3, Agricultural Standard is TBC.	
Nitrite	7.41A	6286 ³ (10/20/88)	1.0		1.0	WQCC Ground Water Standard; Table 1, Human Health Standard is TBC.	Analytical results are total nitrite plus nitrate as nitrogen. Reanalysis is required to determine if proposed nitrite standard is exceeded.
Nitrate	7.41A	6286 ³ (10/20/88)	5	10.0		SDWA MCL (40 CFR 141.11 [b])	Analytical results are total nitrite plus nitrate as nitrogen. Results indicate that proposed nitrate standard is not exceeded.
Chloride	132A	3087BR (02/01/89)	5		250	WQCC Ground Water Standard; Table 1, Human Health Standard is TBC.	Maximum detected concen- tration is below proposed standard.
Fluoride	1.0	6286 ³ (02/16/90)	1		2.0	WQCC Ground Water Standard; Table 3, Agricultural Standard is TBC.	Maximum detected concen- tration is below proposed standard.

TABLE 3-1

**PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS
DETECTED IN BEDROCK GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES
(Continued)**

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (mg/l) ²	Well Designation # & Sample Date	Detection Limit (mg/l)	Proposed ARAR (mg/l)	Proposed TBC (mg/l)	Reference	Comment
<u>Non-Metallic Inorganics (cont.)</u>							
Sulfate	1084A	3486 (11/04/88)	5		250	WOCC Ground Water Standard; Table 2, Secondary Drinking Water Standard is TBC.	
Bicarbonate	530	1487BR ² (09/01/87)	10	NS		No Standard	
TDS	1886A	3486 (02/09/89)	5		1643	WOCC Ground Water Standard; Table 4, TDS Water Quality Standard is TBC.	Proposed standard is calculated from the upper tolerance interval in background bedrock wells. Value includes 95% of the population at 95% confi- dence, multiplied by 1.25.

TABLE 3-1

**PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS
DETECTED IN BEDROCK GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES**
(Continued)

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (pCi/l)	Well Designation # & Sample Date	Detection Limit (pCi/l)	Proposed ARAR (pCi/l)	Proposed TBC (pCi/l)	Reference	Comment
Radionuclides							
Gross Alpha	106 ± 18	4086 (10/27/87) and 6286 ³ (04/09/87)	2	15		SDWA MCL (40 CFR 141.15[b])	
Gross Beta	207 ± 15	4086 (10/27/87)	4	4 (mrem/yr)		SDWA MCL (40 CFR 141.16[a]).	
Pu ^{239,240}	0.07 ± 0.05	2387BR (08/12/88)	0.01		15	WQCC Statewide Standard for Radionuclide Materials in Ground Water is TBC.	Maximum detected concen- tration is below proposed standard. Concentration is estimated below minimum detectable limit (MDL).
Am ²⁴¹	0.1 ± 0.16	4587BR (04/19/88)	0.01		0.05	WQCC Surface Water Standard is TBC.	Maximum detected concen- tration is below proposed standard.
H ¹	220	6286 ³ (07/15/88) and 4086 (03/11/88)	400	20000		SDWA MCL (40 CFR 141.16[b]).	
Cs ¹³⁷	0.3 ± 0.5	6286 ³ (06/10/89)	1	NS		No Standard	Concentration is estimated below MDL.
Ra ²²⁶	0.4 ± 0.4	4587BR (06/13/89)	0.5	5		SDWA MCL (40 CFR 141.15[a]).	Maximum detected concen- tration is below proposed standard. Concentration is estimated below MDL.

TABLE 3-1

**PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS
DETECTED IN BEDROCK GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES
(Concluded)**

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (pCi/l) ¹	Well Designation # & Sample Date	Detection Limit (pCi/l)	Proposed ARAR (pCi/l)	Proposed TBC (pCi/l)	Reference	Comment
Radionuclides (cont.)							
⁹⁰ Sr	1.2	3486 (10/17/87) and 4587BR (10/20/89)	1	8		SDWA MCL (40 CFR 141.16(b)).	Maximum detected concentration is below proposed standard.
U ^{total}	21.8 ± 1.9	6286 ³ (06/10/89)	1.8		5	CDH Surface Water Standard is TBC.	

¹ - Maximum compound concentrations determined from data collected through the fourth quarter of 1989.

² - Maximum compound concentrations determined from limited well data through the first quarter of 1990.

³ - Monitor Wells 1487BR and 6286 are screened at relatively shallow depths in lower intervals of weathered sandstone that supercrop on the hillside south and southeast of the 903 pad. Both the bedrock and alluvial workplans will commonly utilize the laboratory data from these two wells because of the potential cross connection between the lower and upper hydrostratigraphic units where these two wells are located.

A - Acceptable with qualifications.

B - Compound also present in blank.

D - Value was for duplicate sample. Original sample result was 5U ppb.

J - Estimated below detection limit.

U - Detection limit.

V - Validated.

3.2 THE ARAR PROCESS

3.2.1 ARARs

"Applicable requirements," as defined in 40 CFR 300.5, are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable." "Relevant and appropriate requirements," also defined in 40 CFR 300.5, are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws, that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate." The most stringent promulgated standards are applied as ARAR (Preamble to NCP, 55 FR 8741).

3.2.2 TBCs

In addition to applicable or relevant and appropriate requirements, advisories, criteria, or guidance may be identified to be considered (TBC) for a particular release. As defined in 40 CFR 300.400(g)(3), the TBC category consists of advisories, criteria, or guidance developed by EPA, other federal agencies, or states that may be useful in developing remedies. Use of TBCs is discretionary rather than mandatory, as is the case with applicable or relevant and appropriate requirements.

3.2.3 ARAR Categories

In general, there are three categories of ARARs. These categories are:

1. Ambient or chemical-specific requirements
2. Location-specific requirements
3. Performance, design, or other action-specific requirements

ARARs are generally considered to be dynamic in nature in that they evolve from general to very specific in the CERCLA site cleanup process. Initially, during the RI work plan stage, probable chemical-specific ARARs may be identified, usually based on a limited amount of data. Chemical-specific ARARs at this

point have meaning only in that they may be used to ensure appropriate detection limits have been established so that data collected in the RI will be amenable for comparison to ARAR standards. It is also appropriate to identify location-specific ARARs early in the RI process so that information may be gathered to determine if restrictions may be placed on the concentration of hazardous substances or on the conduct of an activity solely because it occurs in a special location.

Chemical-specific ARARs do not currently exist for soils. As the remedial investigation proceeds, information will become available from the risk assessment which will allow a determination of acceptable contaminant concentrations in soils to ensure environmental "protectiveness."

3.2.4 Feasibility Study ARAR Requirements

Development of a preliminary list of potential chemical-specific ARARs in the RI process also allows the establishment of a list of preliminary remediation goals in the early FS process, which is essentially a tentative listing of contaminants together with initially anticipated cleanup concentrations or risk levels for each medium. Preliminary remediation goals serve to focus the development of alternatives on remedial technologies that can achieve the remediation goals, thereby limiting the number of alternatives to be considered in the detailed remedial alternative analysis, conducted later in the FS process. As more information becomes available during the RI stage, chemical-specific ARARs may become more refined as constituents are added or deleted, which is often the case when the RI takes place in numerous phases. Once data collection is complete, revised chemical-specific ARAR selection may be proposed.

When the data collection is complete, it is also appropriate to refine location-specific ARARs which may affect the development of remedial alternatives. During development of remedial action alternatives at the beginning of the FS process, a preliminary consideration of action-specific ARARs will be conducted. As remedial alternatives are screened during the FS, action-specific ARARs will be identified. When a detailed analysis of the remedial alternatives is conducted, all action-specific ARARs are refined and finalized with respect to each alternative before a comparison of alternatives begins. At this point, a discussion is provided in the FS report for each remedial alternative regarding the rationale for all ARAR determinations.

3.3 REMEDIAL ACTION

CERCLA §121 specifically requires attainment of all ARARs. Moreover, as explained in the preamble to the National Contingency Plan (NCP) (55 FR 8741), in order to attain all ARARs, a remedial action must comply with the most stringent requirement, which then ensures attainment of all other ARARs. Furthermore, CERCLA requires that the remedies selected attain ARARs and be protective of human health and the environment. Consequently, preliminary remediation goals based on ARARs will require modification as new information and data are collected in the RI, including the baseline risk assessment (to

be conducted), when ARARs are not available or are determined to be inadequate for protection of human health and the environment.

3.3.1 Remediation Goals

Development of remediation goals is actually a portion of the overall development of remedial action objectives, which ultimately will define the required endpoint of the selected remedial action. As stated in the preamble to the NCP (55 FR 8713), "remedial action objectives are the more general description of what the remedial action will accomplish. Remediation goals are a subset of remedial action objectives and consist of medium-specific or operable unit-specific chemical concentrations that are protective of human health and the environment and serve as goals for the remedial action. The remedial action objectives ... should specify: (1) the contaminants of concern, (2) exposure routes and receptors, and (3) an acceptable contaminant level or range of levels for each exposure medium (i.e., a preliminary remediation goals)." According to 40 CFR 300.430 (e)(2)(i), "Remediation goals shall establish acceptable exposure levels that are protective of human health and the environment and shall be developed by considering the following":

- (A) ARARs (chemical-specific) and
 - (1) Acceptable exposure levels for systemic toxicants,
 - (2) Acceptable exposure levels for known or suspected carcinogens,
 - (3) Technical limitations (e.g., detection limits),
 - (4) Uncertainty factors, and
 - (5) Other pertinent information.
- (B) Maximum Contaminant Level Goals (MCLGs) (or Maximum Contaminant Levels -- MCLs -- where MCLGs are zero or where MCLGs are not relevant and appropriate), where relevant and appropriate.
- (C) Acceptable exposure levels where multiple contaminants or multiple exposure pathways will cause exposure at ARAR levels will result in cumulative risk in excess of 10^{-4} .
- (D) Clean Water Act (CWA) Water Quality Criteria, where relevant and appropriate.
- (E) A CERCLA Alternative Concentration Limit (ACL) established pursuant to CERCLA § 121(d)(2)(B)(ii).
- (F) Environmental evaluations, performed to assess specific threats to the environment.

Once a remedial action alternative is formally selected, all chemical-, location-, and action-specific ARARs have also been defined in final form. If it is found that the most suitable remedial alternative does not meet an ARAR, the NCP, at 40 CFR 300.430 (f)(1)(ii)(C), provides for waivers of ARARs under certain circumstances, such as technical impracticability, risk, or inconsistent application of state requirements. From this point, the alternative will become the final remedy as it is incorporated into the Record of Decision (ROD). Once the final ROD has been signed, requirements may be modified only when they are determined to be applicable or relevant and appropriate and necessary to ensure that the remedy is protective of human health and the environment (40 CFR 300.430(f)(1)(ii)).

3.4 OPERABLE UNIT 2 BEDROCK GROUNDWATER ARARs

The ARARs for bedrock groundwater listed in Table 3-1 were developed using the ARARs rationale described above and were identified by examining the following promulgated standards:

- Safe Drinking Water Act (SDWA) MCLs
- RCRA Subpart F concentration limits (40 CFR 264.94)

3.4.1 Safe Drinking Water Act MCLs

The NCP [55 FR 8848; 40 CFR 300.430 (e)] requires that, in development of alternatives for final remediation, the following be considered for current or potential sources of drinking water: attainment of MCLGs or MCLs, if MCLGs are zero; and attainment of Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) where relevant and appropriate. Because groundwater at Operable Unit 2 is a potential source of drinking water, the MCLGs (or MCLs) should be attained. The AWQC are not ARARs and are not considered with respect to groundwater, since they are intended for the protection of surface water relative to fish ingestion and drinking water or only fish ingestion. Therefore, it is inappropriate to apply such criteria to groundwater.

3.4.2 RCRA Groundwater Protection Standards

Owners or operators of facilities that treat, store, or dispose of hazardous waste must ensure that hazardous constituents listed in 6 CCR (Colorado Code of Regulations) 1007-3 and 40 CFR 261, Appendix VIII entering the groundwater from a regulated unit do not exceed concentration limits (6 CCR 1007-3 and 40 CFR 264.94) at the point of compliance in the uppermost aquifer. The concentration limits include standards for 14 compounds (these standards are equivalent to SDWA MCLs and are identified at 40 CFR 264.94, Table 1), with background or alternate concentration limits (ACLs) used as the standard for the other RCRA Appendix VIII (40 CFR Part 261) constituents or Appendix IX (40 CFR Part 264) constituents (TBC background groundwater values for RCRA Subpart F are applied using maximum concentrations from

background groundwater in both the alluvial and bedrock units at RFP). These concentration limits apply to RCRA-regulated units subject to permitting/closure (landfills, surface impoundments, waste piles, and land treatment units) that received RCRA hazardous waste after July 26, 1982. As a result, these RCRA Subpart F (40 CFR Part 264) regulations are considered relevant and appropriate for groundwater remediation.

3.4.3 RCRA Alternate Concentration Limits

As discussed above, RCRA (40 CFR Part 264) Subpart F requires that corrective actions be taken if hazardous constituents are found to exist at the point of compliance in excess of the established constituent concentrations. Although these constituent concentrations are specifically comprised of RCRA Subpart F, Table 1 constituents, Appendix VIII (40 CFR Part 261), or Appendix IX (40 CFR Part 264) constituent background values, Subpart F does provide a mechanism for variances from these standards. According to 40 CFR 264.94(b), an ACL may be established for a hazardous constituent if it is determined that attainment of a RCRA Subpart F, Table 1 constituent standard or background standard is not necessary to ensure adequate protection of human health and the environment. Furthermore, EPA has stated that for potential drinking water sources, the Agency's preference is to set remediation levels that are the equivalent of health-based ACLs under RCRA (55FR 8666). Therefore, it is inappropriate to establish background as an ARAR unless it may be determined through risk assessment that attainment of background is necessary for adequate protection of human health and the environment. Accordingly, hazardous constituent background values will be applied as TBC until such time as risk assessment information indicates some other alternative standard is necessary to ensure protectiveness. Alternatively, when a standard listed in 40 CFR 264.94, Table 1 has been established for a constituent, the Table 1 standard is considered to be relevant and appropriate. Table 3-1, however, will identify SDWA MCLs rather than RCRA 40 CFR 264.94 Table 1 standards, since the RCRA Table 1 standards are only a subset of all the SDWA MCLs.

3.4.4 Colorado Water Quality Control Commission Groundwater Standards

The Colorado Water Quality Control Commission (WQCC) state-wide groundwater standards are applied as TBC since they are not yet enforceable. Similarly, since groundwater at Rocky Flats Plant has not been classified, the use-specific standards in Tables 1-4 of the WQCC Basic Standards for Groundwater at 3.11.0 (5 CCR 1002-8) will also be applied as TBC where ARARs are not available.

Of the elements/compounds detected in groundwater at Operable Unit 2, there are no ARARs for calcium, magnesium, molybdenum, potassium, sodium, bicarbonate, strontium, acetone, methylene chloride, and carbon disulfide. However, the Total Dissolved Solids (TDS) TBC establishes the acceptable aggregate concentration for the above major metal ions (excluding strontium). For the volatile organic compounds, the RCRA (40 CFR Part 264) Subpart F standard of background (detection limit) is applied as TBC.

3.4.5 Operable Unit 2 ARARs Summary

Table 3-1 shows that certain volatile organics, metals, and major ions that were analyzed have exceeded potential chemical-specific ARARs at some locations within Operable Unit 2. This does not indicate that releases of these constituents are occurring, for the concentrations of some substances may be due to a past release or to natural geochemical processes. The listing of Table 3-1 has been presented to identify parameters for which analysis should be conducted in Phase II and to identify the minimum acceptable detection limits for analytes found in Operable Unit 2 bedrock groundwater. The FS will evaluate technologies that address these constituents.

Note that chemical data from monitoring wells 6286 and 1487BR are included in both the alluvial and bedrock work plans for ARARs identification. Well 6286 is considered to be in the upper hydrostratigraphic unit (HSU) while Well 1487BR is a lower-HSU well based on the HSU delineation shown in Figure 1-1. However, both of these wells are relatively shallow wells screened in lower intervals of weathered sandstone that subcrop on the hillside south and southeast of the 903 Pad. As a result, these wells represent a potential cross connection between the upper and lower HSUs, as described in the site conceptual model (Figure 2-24).

DATA NEEDS AND DATA QUALITY OBJECTIVES (DQOs)

The primary objective of a RFI/RI is to collect the data necessary to determine the nature, distribution, and migration pathways of contaminants. This information is used to support a baseline risk assessment which determines the need for remediation and evaluates risks associated with various remedial alternatives. Five general goals of a RFI/RI are (EPA 1988a):

- Characterize site physical features
- Define contaminant sources
- Determine the nature and extent of contamination
- Describe contaminant fate and transport
- Provide a baseline risk assessment

This section of the RFI/RI workplan summarizes the site conceptual model developed in Section 2.0 and identifies data needs and use of data to meet the outlined objectives.

4.1 SITE SPECIFIC RFI/RI DQO PROCESS

Through application of the data quality objectives (DQOs) process, site-specific RFI/RI DQOs are established, and data needs are identified for achieving identified goals. DQOs are qualitative and quantitative statements that describe the quality and quantity of data required by the RFI/RI (EPA 1987). These determination are facilitated through the development of DQOs.

DQOs are developed using the following three-stage process:

- **STAGE 1 - Identify decision types**
 - identify and involve data users
 - evaluate available data
 - develop conceptual model
 - specify objectives/decisions

- STAGE 2 - Identify data uses and needs
 - identify data uses
 - identify data types
 - identify data quality needs
 - identify data quantity needs
 - evaluate sampling/analysis options
 - review PARCC parameters
- STAGE 3 - Design data collection program
 - assemble data collection components
 - develop data collection documentation

The three stages are implemented for each phase of the RFI/RI. The DQO stages are undertaken in an interactive and iterative manner whereby all the elements of the DQO process are continually being reviewed and applied during the execution of the data collection activities. Throughout the RFI/RI, these stages occur in a natural progression and flow together without a formal stage delineation. It may not be possible to identify all data needs during the RFI/RI activity. Data needs will become more apparent as additional data are obtained and evaluated.

4.2 SUMMARY OF EXISTING SITE DATA AND CONCEPTUAL MODEL

The existing data have been evaluated and support the following tentative conclusions:

- The groundwater in the upper hydrostratigraphic unit (HSU) contains volatile organic compounds. The principal volatile organic compounds present as dissolved constituents are tetrachloroethylene (PCE), trichloroethylene (TCE) and carbon tetrachloride (CCL₄). Although areas of relatively high concentrations of these dissolved contaminants have been delineated, their extent in the upper HSU has not been determined. Although non-aqueous phases of volatile organic contaminants have not been identified in the subsurface in the past, considering the reported volumes of contaminants that may have been spilled or leaked onto the site, there appears to be a potential for dense, non-aqueous phase liquids to be present in localized depressions in the relatively permeable portions of the upper HSU and in weathered or fractured claystone at the bottom of the uppermost unconfined aquifer.
- Relatively low concentrations of volatile organic compounds have been detected in samples of groundwater from four wells screened in the unweathered claystone and lower sandstone

bedrock. These four wells are 1887BR, 2087BR 3487BR, and 4086BR. For the most part, these data have not been validated. There is a potential for contaminated groundwater in the unconfined groundwater flow system to enter lower sandstones where they subcrop beneath relatively shallow colluvium south and southeast of the 903 Pad area. Wells constructed prior to 1986 may also represent a potential pathway of contamination from the upper HSU to the lower HSU(s).

- The predominant component of the groundwater hydraulic gradient in the bedrock is potentially downward. The horizontal component of the hydraulic gradient appears to be generally toward the east. However, in general, the bedrock groundwater flow regime is not well understood and gradients in the deeper sandstones are not known. At present, it is believed that the majority of bedrock groundwater flow occurs laterally in the lower sandstones. The low hydraulic conductivity of the claystone impedes the downward flow of groundwater.
- Considering the proximity of Operable Unit 1 (881 Hillside) and its location to the west of the 903 area, there appears to be a potential for contamination from topographically or hydraulically upgradient sources to be present. Lower sandstones beneath the 881 Hillside site may be upgradient of lower sandstones beneath Operable Unit 2.

4.3 SITE-SPECIFIC PHASE II RFI/RI (BEDROCK) OBJECTIVES AND DATA NEEDS

This section of the Phase II Bedrock RFI/RI Work Plan establishes the objectives and data needs for achieving identified goals. Based on existing data and on the site conceptual model, site-specific RFI/RI objectives and data needs associated with identifying potential sources of bedrock contamination and nature and extent of contamination in the bedrock are shown in Table 4-1. The specific plans and rationale for obtaining the required data are presented in the Field Sampling Plan, Section 8.0.

Data of a quality consistent with the objectives specified in Table 4-1 will be collected in accordance to the Rocky Flats Plant Environmental Restoration (ER) Program Standard Operating Procedures (SOPs) and through adherence to the Rocky Flats Plant ER site-wide Quality Assurance Project Plan (QAPjP). Chemical analyses will be performed in accordance with General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G 1990f).

Analytical methods with detection limits below or near potential chemical-specific ARARs (see Section 3.0) will be used to facilitate comparisons of resulting data to potential ARARs. Table 4-2 summarizes the required analytical levels referenced in Table 4-1.

TABLE 4-1

DATA NEEDS AND DATA QUALITY OBJECTIVES (DQOs)

Data Need	Sample/Analysis Method	Analytical Level	Data Use
CHARACTERIZE PHYSICAL FEATURES			
<ul style="list-style-type: none"> Delineate and characterize physical nature of sandstone units 	<ul style="list-style-type: none"> Boreholes in appropriate areas to refine existing geologic model. Combine information on sandstone units from Geologic Characterization Report with high-resolution seismic profiling data. Laboratory classification testing. Borehole and laboratory permeability testing. 	I & II	<ul style="list-style-type: none"> Site Characterization Alternatives Evaluation
<ul style="list-style-type: none"> Delineate and characterize physical nature of weathered claystone/siltstone 	<ul style="list-style-type: none"> Borehole logging of weathered zone of bedrock. Borehole/well hydraulic conductivity testing. Laboratory classification testing. 	I & II	<ul style="list-style-type: none"> Site Characterization Alternatives Evaluation
<ul style="list-style-type: none"> Characterize physical nature of unweathered claystone/siltstone 	<ul style="list-style-type: none"> Borehole logging of unweathered bedrock. Borehole/well hydraulic conductivity testing. Laboratory classification testing. 	I & II	<ul style="list-style-type: none"> Site Characterization Alternatives Evaluation
<ul style="list-style-type: none"> Develop model of bedrock groundwater flow regime that addresses flow directions, velocities, gradients, and interaction with surface water and groundwater in the upper HSU 	<ul style="list-style-type: none"> Analysis of water level and hydraulic conductivity data from new and existing wells screened in appropriate HSUs. Must consider geometry of HSUs. Combine with results of upper HSU groundwater flow model (which is intended to evaluate interconnection of upper and lower HSUs). 	I	<ul style="list-style-type: none"> Site Characterization Alternatives Evaluation

TABLE 4-1

DATA NEEDS AND DATA QUALITY OBJECTIVES (DQOs) (Continued)

Data Need	Sample/Analysis Method	Analytical Level	Data Use
CHARACTERIZE AND DELINEATE CONTAMINANT SOURCES			
<ul style="list-style-type: none"> Plume areas in upper HSU 	<ul style="list-style-type: none"> Alluvial RFI/RI will characterize plumes of dissolved contaminants in groundwater in the upper HSU. May be potential for additional wells/boreholes near alluvial/bedrock contact and analytical testing on soil and groundwater samples. Need to consider the potential for existing wells, particularly those constructed prior to 1986, to act as conduits across confining layers resulting in cross-contamination. 	I & II (field) IV (analytical)	<ul style="list-style-type: none"> Site Characterization Alternatives Evaluation Risk Assessment
<ul style="list-style-type: none"> Dense non-aqueous phase liquids pooled or flowing in depressions or channels in bottom of upper HSU 	<ul style="list-style-type: none"> Alluvial RFI/RI will address but may not fully characterize dense non-aqueous phase liquids since occurrence will tend to be near alluvial/bedrock contact. Boreholes and wells with analytical testing on soil/liquid samples will be used. Water sampling will check for immiscible phases of contaminants. 	I & II (field) IV (analytical)	<ul style="list-style-type: none"> Site Characterization Alternatives Evaluation Risk Assessment
<ul style="list-style-type: none"> Offsite sources located topographically or hydraulically upgradient 	<ul style="list-style-type: none"> Boreholes and wells with analytical testing on soil and groundwater samples. Limited evaluation of conditions at the upgradient (west) end of Operable Unit 2 will be conducted initially. More detailed characterization of potential upgradient sources will be required only if interim findings demonstrate the need to gather additional data. 	I & II (field) IV (analytical)	<ul style="list-style-type: none"> Site Characterization Alternatives Evaluation Risk Assessment

TABLE 4-1

DATA NEEDS AND DATA QUALITY OBJECTIVES (DQOs) (Continued)

Data Need	Sample/Analysis Method	Analytical Level	Data Use
CHARACTERIZE NATURE AND EXTENT OF CONTAMINATION			
<ul style="list-style-type: none"> Determine whether the contamination in the upper HSU has migrated into the bedrock and characterize the horizontal and vertical extent of any migration 	<ul style="list-style-type: none"> Drilling of boreholes into the bedrock to collect soil samples. Lower sandstone and weathered and unweathered claystone/siltstone will be sampled. 	IV V (radiological analyses)	<ul style="list-style-type: none"> Site Characterization Risk Assessment Fate and Transport Modeling Alternatives Evaluation
	<ul style="list-style-type: none"> Installation of and sampling of monitoring wells with screened intervals in the intervals of concern to evaluate groundwater contamination. Field screening using GC headspace techniques on samples of the bedrock from the boreholes will be used to assist in targeting well screen intervals. Analyses will emphasize volatile organic compounds and radiological constituents. Selected sites will be analyzed for full TCL and TAL. 	II (Field GC screening) IV V (radiological analyses)	
<ul style="list-style-type: none"> Assess the role of the lower sandstones and weathered siltstone/claystone in the transport of contaminants 	<ul style="list-style-type: none"> Boreholes will be drilled into the lower sandstones and weathered claystone/siltstone. Areas of potentially subcropping lower sandstones will be explored and characterized. Conduct analytical testing on the samples. 	IV V (radiological analyses)	<ul style="list-style-type: none"> Site Characterization Risk Assessment Fate and Transport Modeling Alternatives Evaluation

TABLE 4-1

DATA NEEDS AND DATA QUALITY OBJECTIVES (DQOs)
(Concluded)

Data Need	Sample/Analysis Method	Analytical Level	Data Use
	<ul style="list-style-type: none"> Install and sample monitoring wells in the lower sandstone and weathered claystone/siltstone. Field screening using GC headspace techniques on samples of the bedrock from the boreholes will be used to assist in targeting well screen intervals. This will include wells near subcrop areas to evaluate hydraulic gradients, groundwater flow directions, potential hydraulic connection with uppermost aquifer, and groundwater quality based on analytical testing. 	II (Field GC screening) IV V (Radiological analyses)	

Note: Summary of analytical levels given in Table 4-2.

TABLE 4-2
SUMMARY OF ANALYTICAL LEVELS

Required Analytical Level	Task
Level I (Field Screens)	<ul style="list-style-type: none"> • Water level measurement • pH measurement • Eh measurement • Screening for organics (OVA/HNu) • Screening for radionuclides (beta-gamma) • Temperature • Specific conductance • Screening for buried objects (magnetometer, pipe locator)
Level II (Field Analyses)	<ul style="list-style-type: none"> • Screening for organics (GC) • Screening for metals (ICP) • Screening for radionuclides (gross beta/gross alpha gamma spec) • Analysis of engineering properties
Level III (Laboratory Analyses using EPA Standard Methods)	<ul style="list-style-type: none"> • Major ion analysis • Organics analysis • Inorganics analysis
Level IV (Laboratory Analyses using EPA CLP Methods)	<ul style="list-style-type: none"> • Analysis of Target Compound List (TCL) and Target Analyte List (TAL)
Level V (Nonstandard Analyses)	<ul style="list-style-type: none"> • Radiological analyses • Chemical analyses requiring modification of standard methods • Special Analytical Services (SAS)

Source: EPA (1987)

Note: Specific methods described in SOPs and/or QAA.

The following is a list of tasks to be accomplished during the RFI/RI for Operable Unit 2. Each task as discussed in detail in the Phase II Bedrock RFI/RI Work Plan will be coordinated with the corresponding task in the Phase II RFI/RI Alluvial Work Plan.

5.1 TASK 1 - PROJECT PLANNING

The project planning task includes all efforts required to initiate both the alluvial and bedrock components of this Phase II RFI/RI of Operable Unit 2. Activities undertaken for this project have included a review of the Phase I RI results as well as other previous investigation results, review of historical aerial photography, preliminary evaluation of ARARs, and scoping of the Phase II RI. Results of these activities are presented in the alluvial work plan (EG&G 1990c) and in Sections 1.0 (Introduction) and 2.0 (Site Characterization).

During the Phase I RI, a complex depositional pattern was recognized in the bedrock beneath the 903 Pad, Mound, and East Trenches areas. This work plan incorporates the results of on-going geologic characterization efforts (EG&G 1990a and 1990b) intended to define the location, extent, and orientation of bedrock sandstone units, and outlines further work to refine the site bedrock geologic model. The geologic characterization has been combined with analytical chemistry data obtained during Phase I to develop a model of the nature and extent of contamination.

Two project planning documents, including this Work Plan, have been prepared which pertain to this Phase II RI as required by the draft Inter-Agency Agreement (IAG) between DOE, EPA, and CDH. This Work Plan presents results of the project planning task in addition to plans for the Phase II RFI/RI. A Field Sampling Plan (FSP) included in this document presents the locations, media, and frequency of sampling efforts. The second document required by the IAG is a Sampling and Analysis Plan (SAP). Included in the SAP are a Quality Assurance Project Plan (QAPP) and Standard Operating Procedures (SOPs) for all field activities.

5.2 TASK 2 - COMMUNITY RELATIONS

In accordance with the draft IAG, the Communications Department at Rocky Flats is developing a Plant-wide Community Relations Plan (CRP) to actively involve the public in the decision-making process as it relates to environmental restoration activities. A Draft Community Relations Survey Plan has been completed and forwarded to EPA, CDH, and the public for review. This Phase II RFI/RI work plan specifies activities planned to complete the Plant-wide CRP, including plans for community interviews. The

draft CRP will be completed in September 1990 in accordance with the draft IAG schedules. Accordingly, a site-specific CRP is not required for Operable Unit 2.

The Communications Department also is continuing other public information efforts to keep the public informed of environmental restoration activities and other issues which relate to Plant operations. A Speakers Bureau program sends speakers to civic groups and educational organizations, while a public tour program allows the public to visit Rocky Flats. Road tours of areas such as the 903 Pad, Mound, and East Trenches areas are common during public tours, as well as other tours arranged for public officials. An Outreach Program also is in place according to which Plant officials will visit elected officials, the news media, and business and civic organizations to further discuss issues related to Rocky Flats and environmental restoration activities. The Communications Department also receives numerous public inquiries, which are answered through telephone conversations or by sending written informational materials to the requestor.

5.3 TASK 3 - FIELD INVESTIGATION

The Phase II RFI/RI (Bedrock) field investigation is designed to meet the objectives outlined in Section 4.0. The following activities will be performed as part of the field investigation:

- Drill and sample soils and bedrock and conduct geotechnical and geochemical laboratory testing on samples to further characterize the potential contaminants that may be present within the pore spaces in bedrock or that may be present as separate phase immiscible liquids.
- Drill and log borings and install monitoring wells to further characterize the distribution of aquifer and aquitard zones within the bedrock. Field volatile organic screening by GC methods will be used to assist in determining well screen intervals.
- Perform in situ hydraulic conductivity testing in borings and wells to further characterize the hydraulic connection between surficial materials and bedrock and to further characterize groundwater flow rates
- Collect water level measurements in the monitoring wells to further characterize hydraulic gradients that will be used to evaluate groundwater flow directions.
- Collect and analyze groundwater samples from monitoring wells to characterize the nature and extent of bedrock groundwater contamination.

Sample locations, frequency, and analyses are presented in Section 8.0. All field activities will be performed in accordance with the Rocky Flats Plant ER Program SOP.

5.4 TASK 4 - SAMPLE ANALYSIS AND DATA VALIDATION

Analytical methods for chemical analyses are provided in the ER Program Quality Assurance Project Plan (QAPjP). Also provided in this document are the analytical detection limits, sample container and volume requirements, preservation requirements, and sample holding times. Project specific requirements are included in the Quality Assurance Addendum, Section 9.0 of this Work Plan.

Data will be reviewed and validated by the ER Program staff. Results of data review and validation activities will be documented in data validation reports. EPA data validation functional guidelines will be used for validating organic and inorganic (metals) data (EPA 1988b). Validation methods for radiochemistry and major ions data have not been published by the EPA; however, data and documentation requirements have been developed by ER Program QA staff. Data validation methods for these data are derived from these requirements. Details of the data validation process are described in the QAPjP.

5.5 TASK 5 DATA EVALUATION

Data collected during the Phase II bedrock RI will be incorporated, with Phase II alluvial data, into the existing database and used to better define site characteristics, source characteristics, the nature and extent of contamination, and to support the baseline risk assessment and evaluation of proposed remedial alternatives.

5.5.1 Site Characterization

Geologic and hydrologic data will be incorporated into appropriate site maps and cross-sections. Geologic data will be used to detail the stratigraphy of the bedrock in the 903 Pad, Mound, and East Trenches areas. Hydrogeologic data will be used to characterize the subsurface geometry of aquifer and aquitard zones and groundwater flow in the bedrock. This characterization will include gathering data on effective porosities, hydraulic conductivities, and hydraulic gradients that will be used as a basis for evaluating flow directions, the interaction between alluvial and bedrock groundwater, groundwater velocities, and contaminant migration rates.

5.5.2 Source Characterization

The results of the alluvial RFI/RI will be carefully evaluated to identify potential sources of bedrock contamination. The potential sources evaluated will include: (1) plumes of dissolved (aqueous phase) contaminants in the upper HSU, (2) pools or pockets of non-aqueous phase contaminants near the bottom of the upper HSU, and (3) unidentified off-site sources located topographically and/or hydraulically upgradient of the site.

Analytical data from the source boreholes will be used to :

- Confirm IHSS locations
- Characterize the nature of source contaminants
- Characterize the lateral and vertical extent of source contaminants
- Determine the maximum onsite contaminant concentrations
- Quantify the volume of source materials

At those IHSS locations which are trenches, geologic data from the source boreholes will determine the trench depths and characterize trench contents.

5.5.3 Nature and Extent of Contamination

Analytical data from samples of bedrock groundwater will be used to characterize the nature and extent of contamination. The criteria for the identification of contamination will be analyte-specific, as discussed in Subsection 2.2.2, Background Characterization. Essential to the implementation of these statistical techniques for groundwater and borehole samples is the categorization of each analytical data set into appropriate hydrogeologic units (e.g., the samples from similar sandstone lithologic units or claystone would be categorized together). The identification of the appropriate geologic unit will be based on geological data collected during the Phase II RFI/RI. The natural range of background concentrations of inorganic parameters will be further characterized and evaluated in the context of the potential role of evaporative concentrations as a mechanism for localized occurrences of inorganic constituents at high concentrations at outcrops or shallow subcrops.

The extent of contamination will be delineated through the use of isopleth maps and cross sections. The possible use of kriging or other computerized calculation methods to contour the isopleths for the most widely distributed contaminants will be investigated. Appropriate statistical techniques will be used to identify and characterize constituent distribution and source areas.

Comparisons of analytical data from alluvial and bedrock groundwater will be made to investigate the movement of contaminants.

5.6 TASK 6 - BASELINE RISK ASSESSMENT

A baseline risk assessment will be prepared for the 903 Pad, Mound, and East Trenches areas as part of the Phase II RI to evaluate the potential threat to the public health and the environment in the absence of remedial action. One risk assessment combining the bedrock and alluvial components of the RFI/RI will be conducted. The baseline risk assessment will provide the basis for determining whether or not remedial action is necessary in the area and serve as the justification for performing remedial action (EPA 1988a).

Several objectives will be accomplished under the risk assessment task including identification and characterization of the following (EPA 1988a):

- Toxicity and concentrations of hazardous substances present in relevant media (e.g., air, groundwater, soil, surface water, sediment, and biota)
- Environmental fate and transport mechanisms within specific environmental media, and cross-media fate and transport, where appropriate
- Potential human and environmental receptors
- Potential exposure routes and extent of actual or expected exposure
- Extent of expected impact or threat and the likelihood of such impact or threat occurring (i.e., risk characterization)
- Level(s) of uncertainty and limitations associated with the above factors

The public health risk assessment and the environmental evaluation will be performed in accordance with EPA and other guidance documents. The risk assessment will address the potential public health and environmental impacts associated with the site under the no-action alternative (no-remedial action taken). This assessment will aid in the selection of site remedies based on the contaminants of concern and the environmental media associated with potential risks to public health and the environment.

5.6.1 Public Health Evaluation

The risk assessment process is divided into four tasks (EPA 1988a), including:

- Contamination identification
- Exposure assessment
- Toxicity assessment
- Risk characterization

The task objectives and description of work for each task are described below.

5.6.1.1 Contaminant Identification

The objective of contaminant identification is to screen the information that is available on hazardous substances or wastes present at the site and to identify contaminants for the risk assessment process.

Previous work characterizing aspects of the Rocky Flats Plant and the surrounding area has been performed. Additional sampling and analysis of various media will take place in order to support the human health risk assessment, the ecological assessment, and to further characterize the site. Reduction in the number of contaminants identified to a list of "contaminants of concern" will be evaluated in accordance with EPA guidance (EPA 1989a).

5.6.1.2 Exposure Assessment

The objectives of the exposure assessment are to identify actual or potential exposure pathways, to identify and characterize potentially exposed populations, and to determine the extent of exposure. An exposure pathway is comprised of four elements:

- 1) A source and mechanism of chemical release to the environment
- 2) An environmental transport medium (e.g., air, groundwater) for the released constituent
- 3) A point of potential contact of humans or biota with the affected medium (the exposure point)
- 4) An exposure route (e.g., inhalation of contaminated dust) at the exposure point

The exposure assessment process will include the following actions:

- Analyze the probable fate and transport of compounds for both the present and the future uses
- Identify the human populations in the area, typical activities that would influence exposure, and sensitive population subgroups
- Identify potential and complete exposure pathways under current and future land use conditions
- Develop exposure scenarios for each identified pathway and select those scenarios that are plausible
- Identify scenarios assuming both existing and potential future uses
- Develop an estimate of the expected exposure levels at the exposure points from the potential release of contaminants

Appropriate exposure scenarios will be identified for the site. Scenarios which could potentially be considered include natural residential, commercial/industrial, and/or recreational use. Factors to be examined in the pathway and receptor identification process will include:

- Location of contaminant source
- Local topography
- Local meteorological data
- Local geohydrology/surface water hydrology
- Surrounding land use
- Local water use
- Prediction of contaminant migration
- Persistence and mobility of migrating contaminants

For each migration pathway and for existing and future land use, receptors will be identified and characterized. Potential receptors will be defined by the appropriate exposure scenarios.

5.6.1.3 Toxicity Assessment

In accordance with EPA's risk assessment guidelines, the projected concentrations of chemicals of concern at exposure points will be compared with ARARs to judge the degree and extent of risk to public health and the environment (including plants, animals, and ecosystems). Because ARARs do not exist for certain media (such as soils) and not all ARARs are health-based, this comparison is not sufficient in itself to satisfy the requirements of the risk assessment process. Moreover, receptors may be exposed to contaminants from more than one medium. Nevertheless, the comparison with standards and criteria is useful in defining the exceedance of institutional requirements. In addition to ARARs listed in Table 3-1, the following criteria will be examined:

- Drinking-water health advisories
- Ambient water quality criteria for protection of human health
- Center for Disease Control and Agency for Toxic Substances and Disease Registry soil advisories
- National Ambient Air Quality Standards

Critical toxicity values (i.e., numerical values derived from dose-response information for individual compounds) will be used in conjunction with calculated media intake determinations to evaluate potential risk. Toxicity reference values from EPA's Integrated Risk Information System (IRIS) will be used in preference to other EPA reference values.

The baseline risk assessment will also include a summary of significant toxicological studies performed for chemicals of concern. The quality of these studies and their usefulness in estimating human health risks will be described. A more detailed explanation of the toxic effects for chemicals of concern will be provided in appendixes to the human health risk assessment and the environmental evaluation. Toxicity reference values will also be summarized. For the human health risk assessment, this will include a brief description of the studies upon which selected reference values were based, the uncertainty factors used to calculate risk reference doses (RfDs), and the EPA weight-of-evidence classification for carcinogens. For those chemicals without EPA toxicity reference values, a literature search, including computer data bases, may be conducted for selected compounds. A toxicity value will then be derived, when possible, from this information. EPA guidance will be followed regarding the appropriateness of the data and the methodologies to be used in deriving reference values. Uncertainties regarding the toxicity assessment will be discussed.

Two types of critical toxicity values will be used:

- The risk reference dose (RfD)
- Slope factor (for carcinogenic chemicals only)

5.6.1.4 Risk Characterization

Risk characterization involves integrating exposure assumptions and toxicity information to quantitatively estimate the risk of adverse health effects. Risk characterization will be performed in accordance with EPA guidance and a quantitative risk estimate will be performed for all chemicals. To assess the potential adverse health effects associated with access to the site, the potential level of human exposure to the chemicals of concern must be determined. Chemical intakes of receptor populations will be calculated separately for all appropriate exposure pathways for chemicals. Then, for each population-at-risk, the total intake by each route of exposure will be calculated by adding the intakes from each pathway. Total oral, inhalation, and dermal exposures will be estimated separately. Because short-term (subchronic) exposures to relatively high concentrations of chemicals may cause different non-carcinogenic effects than those caused by long-term (chronic) exposures to lower concentrations, two intake levels will be calculated for non-carcinogens for each route of exposure to carcinogens. A reasonable maximum estimate of exposure based on the 95 percent upper confidence limit of the analytical data will be used where applicable. Risk will be quantified by comparison of contaminant intakes at exposure points to quantitative criteria for protection of human health RfDs and slope factors.

An uncertainty analysis will be performed to identify and evaluate factors that may produce uncertainty in the risk assessment, such as assumptions inherent in the development of toxicological endpoints (e.g., potency factors, reference doses). If necessary, a health risk assessment will be used to define and evaluate relative health risks associated with the potential remedial alternatives.

5.6.2 Environmental Evaluation

The objective of the environmental evaluation for Operable Unit 2 is to determine if the contaminants have caused or are causing an adverse environmental impact. The data to be collected will be utilized in conjunction with existing data to determine the bio-availability and toxicity of the contaminants to the flora and fauna of the 903 Pad, Mound, and East Trenches areas.

The environmental evaluation will be conducted according to guidance provided in "Risk Assessment Guidance for Superfund," Volume II, Environmental Evaluation Manual (EPA 1989d) as part of the 903 Pad, Mound, and East Trenches areas Phase II RFI/RI. The scope of the investigation will be limited to the use of existing data as is recommended in the cited EPA guidance. The radioecology study (Rocky Flats Plant Radioecology and Airborne Pathway Summary Report [Rockwell International 1986f]), the Final Environmental Impact Statement (DOE 1980), the soils and surface water chemical data, and any biological parameters collected during this environmental evaluation will be utilized to assess both the current and future ecological impacts within Operable Unit 2.

In order to accomplish the work plan objective, a number of activities are prepared and executed. These are briefly described below:

- **Project Preparation.** This activity represents the project planning, preparation of the work plan, and preparation of the sampling and analyses plan (SAP). The SAP incorporates two other supporting documents, the field sampling plan (FSP) and quality assurance project plan (QAPjP). Included also is the review and analysis of existing information, identification of data gaps, and the preparation of a site-specific conceptual model of release, transport, and exposure.
- **Field Investigation.** This activity represents all Phase II remedial investigation and ecological assessment fieldwork, including the installation of monitoring wells, soil borings, sampling and analysis of ground and surface waters, collection and analysis of soil scrapes, collection and analysis of biological samples, and air quality sampling necessary for the baseline risk assessment.
- **Data Analysis.** During data analysis, all collected field data are reduced, evaluated, compared with, and integrated into the existing data bank to provide up-to-date information on conditions. A second activity is to identify and provide data on specific chemical/radiological contaminants, transport mechanisms, and environmental receptors in order to conduct the baseline risk assessment.
- **Environmental Risk Assessment.** The environmental risk assessment incorporates the environmental data gathered in the previous activities, characterizes documented or potential

contaminant exposure pathways and exposure point concentrations, and assesses the risk or threat to wildlife, protected species, or habitats.

- Remediation Criteria. Statutes require the selection of remedial actions sufficient to protect the environment. This activity entails the consideration of federal and Colorado state laws and regulations pertaining to the preservation and protection of natural resources that are applicable for the environmental risk assessment are utilized to the extent they are available. Available data will be evaluated and, to the extent practicable, criteria will be established that address environmental protection.
- Environmental Evaluation Report. This activity entails the preparation of the report that addresses the scope of the investigation, site environmental characteristics and contaminants, characterization of exposure and risk, remediation criteria, conclusions, and limitations of assessment.

5.7 TASK 7 - TREATABILITY STUDIES

This task includes efforts to provide technical support in the form of bench scale treatability tests to the Rocky Flats Plant (RFP) Environmental Restoration Program. These tests are intended to support the Operable Unit 2 bedrock component of the RFI/RI. It is assumed at this time that, if contamination of the bedrock is found, remediation will involve groundwater treatment, possibly in conjunction with containment and monitoring. However, other technologies may be applicable to local areas of relatively high levels of contamination where treatment of the bedrock itself may be feasible.

Treatability studies are conducted primarily to: (1) provide sufficient data to allow treatment alternatives to be fully developed and evaluated during the detailed analysis and to support the design of a selected remedial alternative; and (2) reduce cost and performance uncertainties for treatment alternatives to acceptable levels so that a remedy can be selected. Treatability study requirements are developed during the development and screening of remedial alternatives (Subsection 6.1).

Numerous technologies that appeared to be potentially applicable for treating Operable Unit 2 were screened for treatability testing. Contaminants consist of spent solvents, radionuclides, and oils. The technologies selected for screening were limited to those already commercially established or which have demonstrated potential for processing similar contaminants. Additionally, the technologies considered were required to be readily implementable (i.e., standard pre-engineered units available) within a short time frame. Innovative and alternative technologies were not considered.

Depending on the specific yield of the bedrock matrix considered for remediation, it may be feasible to collect groundwater for treatment above ground. In that case, the following technologies have been identified for potential testing:

- **Chemical Oxidation of Organics** - Chemical oxidation is used to degrade hazardous organic materials to less toxic compounds. Oxidation systems, particularly those using ultraviolet (UV) light, ozone, and hydrogen peroxide, are powerful tools for treating a wide variety of common organic environmental contaminants. Disadvantages are similar to those for inorganic oxidation reduction potential nontarget organics and inorganics can produce undesirable side products and increase oxidant requirements.
- **Granular Activated Carbon (GAC) Adsorption of Organics** - GAC adsorption is the most fully developed and widely used technology for treating groundwater contaminated with organics. It is effective for the removal of a wide range of organics from aqueous waste streams. Bench scale testing would consist of running a series of descriptive tests to determine isotherms for the groundwater contaminants. GAC is typically regenerated with a thermal process and the regeneration process can be performed at either off-site or on-site facilities.
- **Reverse Osmosis** - Reverse osmosis processes involve the use of semipermeable membranes. By applying water pressure greater than the osmotic pressure to one side of the membrane, water is passed through the membrane while particulate, salts, and high molecular weight organics are retained. The retained, highly concentrated solution (retentate) contains dissolved salts, as well as the target contaminants, and requires further treatment or disposal.
- **Air Stripping** - Air stripping is a proven technology for removal of volatile and semivolatile contaminants from water. This process involves the transfer of contaminants from a contaminated liquid phase to a vapor phase by passing the two countercurrent streams through a packed tower. Air emission treatment is generally required with vapor phase activated carbon systems being the most commonly used process for this purpose, but other alternatives, such as oxidation and incineration, exist. The vapor phase treatment unit is generally costly.
- **Distillation** - Distillation is a process that involves separating compounds according to their boiling point characteristics. The primary use of distillation is for reclaiming spent solvents from industrial processes, and it is generally applicable only to rather concentrated solutions. The process can be used to separate various volatile compounds or to separate mixtures of organics into light and heavy fractions. The light fraction can usually be recycled or used as a boiler feed, while the heavy fraction requires further treatment.

- **Biological Reactor** - Depending on the specific yield of the bedrock matrix, it may be possible to extract groundwater and use biological reactors utilizing microorganisms to remove organic contaminants from the water. Most organic contaminants can be biologically degraded by introducing the appropriate microorganisms. High concentrations of some organics and the presence of metals may prove toxic to the organisms, and pretreatment may be required. Several types of aerobic reactors exist, such as activated sludge systems, trickling filters, rotating biological contactors, and immobilized cell reactors. In general, these methods generate large amounts of sludge, requiring disposal.
- **Sorption of Radionuclides** - Sorption of inorganics, metals, and radionuclides is a standard technique for removal and concentration of these contaminants from wastewater. The sorption media are generally chemically regenerated, which results in a concentrated side stream requiring further treatment or disposal. Common and proved sorption processes include ion exchange and GAC, while less proven techniques involve the use of activated alumina, bone char, and proprietary sorption media. Ion exchange and GAC will be addressed separately.

Activated alumina is a porous form of aluminum oxide with a large surface area. For removal of aqueous contaminants, activated alumina is typically used in a column similar to that for ion exchange. It has been proven to be successful in the removal of arsenic and fluoride from groundwater (Rubel 1980). More recently, activated alumina has shown promise in absorbing plutonium from a low-level wastewater effluent at the Hanford Site (Barney et al. 1989). In the same study, plutonium adsorption on bone char adsorbent was the most rapid and gave the highest decontamination factors. Waste stream specific laboratory testing would provide valuable information on the suitability of these sorbents for low-level radionuclide removal.

- **Ion Exchange of Radionuclides** - Ion exchange processes are used for a wide range of water treatment applications, including commonly recognized systems such as demineralizers and water softeners. The goal of an ion exchange system is to remove undesirable ions of a certain type(s) from a solution and replace them with more acceptable ions. Radionuclides are commonly removed from waste streams at nuclear facilities using ion exchange.

Ion exchange resins, particularly anion exchange resins, have been used to recover uranium from mine runoff water for many years. Extensive studies on the laboratory scale report removal of uranium from natural waters as high as 99 percent (Sorg 1988). A small full-scale ion exchange system was capable of removing uranium from drinking water supplies to as low as $1\mu\text{l}$ (Jelinek 1988). Ion exchange resins are typically rechargeable; however, the resins used in radioactive applications are generally only used once and are then disposed of as a solid waste. Although published information in the removal of plutonium from natural waters by ion exchange has not

been found, there is indication that ionized plutonium is removable using this technology (Marston 1990).

In cases where collection of groundwater is not feasible or practical, the following technology was identified for potential testing:

- In Situ Biological Treatment - Depending on the effective porosity of the bedrock, in situ biological treatment may be feasible. In situ biological treatment of groundwater involves the stimulation of biological growth in the contaminated zone in order to reduce the contaminant concentrations. Microorganisms that can use some or all of the contaminants as substrates will normally exist in a contaminated environment. The microorganisms are stimulated to increase their biological growth and consumption of contaminants through addition of essential nutrients. Aerobic treatment systems also require the introduction of oxygen. In situ treatment is dependent on geological and hydrological conditions. The process is relatively inexpensive.
- Vacuum Extraction - Volatile contaminants can be removed from soil using vacuum extraction, which is an in situ treatment technology that involves the air stripping of contaminants by inducing a vapor flow through the soil. Since this technology involves the transfer of contaminants to the vapor, air emission treatment is generally required. The efficiency of the process is highly dependent on geologic conditions, and would tend to be ineffective in low-permeability bedrock.

In cases where contaminants are entrained in bedrock, the bedrock is accessible, and the contamination is of limited areal extent, the following technologies have been identified for potential testing:

- Solidification/Stabilization - Solidification is a process in which contaminants are mechanically bound to solidification agents, reducing their mobility. This produces a solid matrix of waste with high structural integrity. Stabilization usually involves the addition of a chemical reagent to react with the contaminant, producing a less mobile or less toxic compound. Solidification and stabilization are frequently used together and are a well-established method for reducing the mobility and toxicity of hazardous wastes. This process generates large volumes of solidified materials requiring disposal.
- Vitrification - The vitrification process involves heating the waste matrix to a very high temperature and either combining the matrix with molten glass or heating the matrix until it melts. Once cooled, the molten mass solidifies into a stable, noncrystalline solid resistant to leaching of inorganic, metal, and radionuclide contaminants. Organic components are destroyed by pyrolysis. The process can be conducted either in situ or off site; however, the process is generally expensive.

5.8 TASK 8 - REMEDIAL INVESTIGATION REPORT

An RI Report will be prepared to consolidate and summarize the data obtained during Phase I and both the alluvial and bedrock components of the Phase II field work. This report will:

- Describe in detail the field activities which serve as a basis for the RI report. This will include any deviations from the work plan that occurred during implementation of the field investigation.
- Thoroughly discuss site physical conditions. This discussion will include surface features, meteorology, surface water hydrology, surficial geology, groundwater hydrology, demography and land use, and ecology.
- Present site characterization results from all RI investigative activities at Operable Unit 2 in order to further characterize the nature and extent of contamination, as well as the rate of contamination migration. The media to be addressed will include contaminant sources, soils, groundwater, surface water, air, and biota.
- Discuss contaminant fate and transport. This discussion will include potential migration routes, contaminant persistence, and contaminant migration.
- Present a baseline risk assessment. The risk assessment will include human health and environmental evaluations.
- Present a summary of the findings and conclusions and recommendations for the feasibility study.

Some of the above tasks, such as project planning, field investigation, sample analysis, validation and evaluation, and possibly treatability studies, will be implemented separately for the alluvial and bedrock components of the RFI/RI. However, other tasks such as community relations and baseline risk assessment will treat Operable Unit 2 as a whole. A single RFI/RI report will be prepared to consolidate and summarize the data obtained during Phase I and both the alluvial and bedrock components of the Phase II field work.

The following are tasks to be accomplished during the CMS/FS for Operable Unit 2. Each task is discussed in detail in the Phase II Bedrock RFI/RI Work Plan (Task 9) will be coordinated with the corresponding task in the Phase II RFI/RI Alluvial Work Plan.

6.1 TASK 9 REMEDIAL ALTERNATIVES DEVELOPMENT/SCREENING

This section identifies potential technologies applicable to the remediation of contaminated bedrock at Operable Unit 2. The identified technologies are based on the site characterization and the site conceptual model developed in Section 2.0. Identification and screening of technologies and assembling an initial screening of alternatives will be conducted while the RFI/RI is being conducted. However, these activities are early stages of the Feasibility Study and, as such, the results will be presented in the FS report.

This section provides a brief overview of the EPA Superfund process that will be employed to develop and evaluate alternatives for Operable Unit 2 bedrock. The Superfund Comprehensive Environmental Recovery, Compensation and Liability Act of 1980 (CERCLA) process is described in detail in Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988a). The CERCLA process was adopted because it specifies in the greatest detail the steps that should be followed and because the IAG requires general compliance with both RCRA and CERCLA guidance.

The steps followed to develop alternatives for the bedrock beneath the 903 Pad, Mound and East Trenches areas are discussed below:

- Develop site remedial action objectives based on: chemical- and radionuclide-specific standards (when available); site-specific, risk-related factors; and other criteria, as appropriate.
- Develop a list of general types of actions appropriate for the bedrock beneath the 903 Pad, Mound and East Trenches areas (such as containment, treatment, and/or removal) that may be taken to satisfy the objectives defined in the previous step. These general types or classes of action are generally referred to as general response actions in EPA guidance.
- Identify and screen technology groups for each general response action. For example, the general response action of containment can be further defined to include the in situ stabilization of contaminants in a form that is less mobile or immobile in the biosphere.

Other containment alternatives could consist of groundwater barriers such as slurry walls. Screening should eliminate those groups that are not technically feasible at the site.

- Identify and evaluate technology options for each technology group to select a representative process for each group under consideration. Although specific process options are selected for alternative development and evaluation, these processes are intended to represent the broader range of options within a general technology group. For example, a soil bentonite slurry wall may be selected as representative of vertical barriers and would be used for technical and cost comparisons.
- Assemble the selected representative technologies into site closure and corrective action alternatives for the bedrock beneath the 903 Pad, Mound and East Trenches areas and that represent a range of treatment and containment combinations, as appropriate.
- Screen the assembled alternatives against the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo a thorough and extensive analysis, alternatives will be evaluated in less detail than subsequent evaluations.

Effectiveness is an evaluation of the protectiveness of human health and the environment achieved by a remedial alternative action during construction and implementation, and after the response objectives have been met. Evaluation of effectiveness in the short term is based on protection of the community and workers, impacts to the environment, and the time required to meet remedial response objectives. Long-term evaluation of effectiveness addresses the risk remaining to human health and the environment and is based on the percentage of permanent destruction, decreased mobility, and/or reduction in volume of toxic compounds achieved after response objectives have been met.

Implementability is a measure of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action alternative. It is used during screening to evaluate the combinations of process options with respect to the site-specific conditions. Technical feasibility refers to the ability to construct, reliably operate, and comply with action-specific (technology-specific) requirements in order to complete the remedial action. Administrative feasibility refers to the ability to obtain required permits and approvals; to obtain the necessary services and capacity for treatment, storage, and disposal of hazardous wastes; and to obtain essential equipment and technical expertise.

Cost estimates for screening will be derived from cost curves, generic unit costs, vendor information, conventional cost estimating guides, and prior estimates made for Rocky Flats and similar sites, with modifications made for Rocky Flats Plant conditions. Absolute cost accuracy is not necessary. The cost estimates for the alternatives, however, will have the same relative accuracy for comparison and screening.

The cost estimating procedures used during screening are similar to those that will be used during the later detailed alternatives analysis. The later detailed analysis however, will receive more in-depth and detailed cost estimates for the components for each alternative. The screening cost estimates will include capital, operating, and maintenance costs. The operating and maintenance costs will be calculated for the lifetime of the treatment unit operation at the site. Present worth cost analysis will be used for alternatives in order to make the costs for the various alternatives comparable.

Alternatives with the most favorable results from the composite evaluation will be retained for further scrutiny during the detailed analysis. Not more than ten alternatives will be retained for detailed analysis (including containment and no action). At that time, it may be determined that additional site-specific information or technology-specific treatability studies are necessary for an objective detailed analysis. Also, it will be necessary to identify and verify the action-specific applicable or relevant and appropriate requirements (ARARs) that each respective alternative will be required to meet.

At the Phase II RFI/RI Work Plan state, the appropriate level of alternatives analysis requires the listing of general response actions most applicable to the type of site under investigation. General response actions are defined as those broad classes of actions that may satisfy the objectives for remediation defined for Operable Unit 2 bedrock. Table 6-1 provides a list and description of general response actions and typical technologies associated with remediating bedrock and bedrock waters. Table 6-1 also includes a general statement regarding the applicability of the general response action to potential exposure pathways.

The response actions outlined in Table 6-1 must be applied to the potential exposure pathways that will be identified for Operable Unit 2 bedrock. The response actions can individually be capable of providing control over all or some of the potential pathways. Partially effective response actions can be combined to form complementary sets of response actions that provide control over all pathways.

In general terms, potential human exposure may be avoided by prevention of contaminant release, transport, and/or contact. Thus, application of the response actions may be considered at three different points in each potential exposure pathway: (1) at the point where the contaminant could be released from the source, (2) in the transport medium, and (3) at the point where the contact with the released contaminant could be prevented.

While the identification of general response actions is discussed above, the selection of the most appropriate action or combination of actions is not warranted at this time. Site and contaminant data are not sufficient to initiate the screening process. The following data requirements have been established for the Phase II

TABLE 6-1

GENERAL RESPONSE ACTIONS, TYPICAL ASSOCIATED REMEDIAL TECHNOLOGIES, AND EVALUATION

General Response Action	Description	Applicability of General Response Typical Technologies	Action to Potential Pathways
No Action	No remedial action taken at site.	Some monitoring and analyses may be performed.	National Contingency Plan requires consideration of no action as an alternative. Would no address potential pathways, although existing access restriction would continue to control onsite contact.
Access and use restrictions.	Permanent prevention of entry into contaminated area of site. Control of land use.	Site security; fencing; deed use restrictions; warning signs.	Could control onsite exposure and reduce potential for offsite exposure. Site security fence and some signs are in place. Additional short-term or long-term access restriction would likely be part of most remedial actions.
Containment	In-place actions taken to prevent migration of contaminants.	Capping; groundwater containment barriers; soil stabilization; enhanced vegetation.	If applied to source, could be used to control all pathways. If applied to transport media, could be used to mitigate past releases (except air).
Pumping	Transfer of accumulated subsurface or surface contaminated water, usually to treatment and disposal.	Groundwater pumping; leachate collection; liquid removal from surface impoundments.	Applicable to leachate removal prior to in situ treatment or waste removal. Applicable removal of contaminated groundwater and bulk liquids (for example, from buried drums).
Removal	Excavation and transport of primarily nonaqueous contaminated material from area of concern to treatment or disposal area.	Excavation and transfer of drums; soils; sediments; wastes; contaminated structures.	If applied to source, could be used to control all pathways. If applied to transport media, will control corresponding pathway. Must be used with treatment or disposal response actions to be effective.

TABLE 6-1

GENERAL RESPONSE ACTION, TYPICAL ASSOCIATED REMEDIAL TECHNOLOGIES, AND EVALUATIONS
(Continued)

General Response Action	Description	Applicability of General Response Typical Technologies	Action to Potential Pathways
Treatment	Application of technology to change the physical or chemical characteristics of the contaminated material. Applied to material that has been removed.	Incineration; solidification; land treatment; biological, chemical, and physical treatment.	Applied to removed source material, could be used to control all pathways. Applied to removed transport medial, could control air, surface water, groundwater, and sediment pathways.
In Situ Treatment	Application of technologies in situ to change the in-place physical or chemical characteristics of contaminated material.	In situ vitrification; densification; flushing; bioremediation.	Applied to source, could be used to control all pathways. Applied to transport medial, could be used to control corresponding pathways.
Storage	Temporary stockpiling of removed material in a storage area or facility prior to treatment or disposal.	Temporary storage structures.	May be useful as a means to implement removal actions, but definition would not be considered a final action for pathways.
Disposal	Final placement of removed contaminated material or treatment residue in a permanent storage facility.	Permitted landfill; repositories.	With source removal, could be used to control all pathways. With removal of contaminated transport medial, could be used to control corresponding pathway (except air).
Monitoring	Short- and/or long-term monitoring is implemented to assess site conditions and contamination levels.	Sediment, soil, surface water, and groundwater sampling and analysis.	RCRA requires post-closure monitoring to assess performance of closure and corrective action implementation.

RFI/RI effort for characterization of the source and groundwater contaminants and for the preliminary screening of alternatives:

- Describe contaminant fate and transport in bedrock
 - Collect and analyze bedrock and groundwater samples beneath release areas to evaluate contaminant spread
 - Describe and characterize bedrock geohydrology
 - Determine depth to water table and areas of saturated bedrock
- Site physical characterization
 - Groundwater flow regime within bedrock
 - Rock types and general engineering properties
 - Depth to bedrock
 - Depth to groundwater
 - Hydrogeologic boundaries and parameters

These data will enable a thorough comparative evaluation of the technologies with respect to implementability, effectiveness, and cost, and will allow for informed decisions to be made with respect to the selection of preferred technologies. The Field Sampling Plan (Section 8.0) describes the methodology that will be followed to obtain the required information.

6.2 TASK 10 - DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The final step, involving a detailed analysis of each alternative, is performed during the FS. The detailed analysis is not a decision-making process, but it is the process of analyzing and comparing relevant information in order to select a remedial action. Each alternative will be assessed against nine evaluation criteria, and the assessments will be compared to identify the key tradeoffs among the alternatives. Assessment against the nine NCP evaluation criteria, is necessary for the FS and the subsequent Record of Decision (ROD)/Corrective Action Decision (CAD) to comply with the requirements of CERCLA/RCRA. The nine specific evaluation criteria are listed below:

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements (ARARs)
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost

- State acceptance
- Community acceptance

The above criteria are described in the CERCLA EPA guidance document (EPA 1988a). The initial two criteria are considered threshold criteria because these alternatives must be satisfied before further consideration of the remaining criteria. The next five criteria are considered the primary criteria on which the analysis is based. The final two criteria, state and community acceptance, are addressed during the final decision-making process after completion of the FS/CMS. A more detailed description of each criteria follows.

Overall Protection of Human Health and the Environment

The alternatives will be individually analyzed to determine whether they provide adequate protection of human health and the environment. The protectiveness evaluation focuses on how the risks posed by each pathway are being eliminated, reduced, or controlled by treatment, engineering, or institutional measures.

Compliance with ARARs

Each alternative will be analyzed to determine whether it will comply with all state and federal ARARs that have been identified. The analysis will address compliance with chemical-specific, location-specific and action-specific ARARs. If an alternative will not comply with an ARAR, the FS report will present the basis for justifying a waiver.

Long-Term Effectiveness and Permanence

This criterion assesses the risks that remain at the site after the response objectives have been met. The risks associated with any remaining untreated wastes or treatment residuals will be evaluated. For each alternative, the magnitude of the residual risk and the reliability and adequacy of the controls used to manage untreated wastes and treatment residuals will be addressed.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This criterion evaluates the statutory preference of selecting remedial actions that permanently reduce toxicity, mobility, or volume of the hazardous materials. Factors evaluated for each alternative will include the proposed treatment process and the materials treated; the quantity of materials to be treated or destroyed, and how the primary hazardous threat will be addressed; the estimated degree of the reduction in toxicity, mobility, or volume that will be achieved; the extent to which the treatment will be irreversible; the type and quantity of treatment residuals that will remain following treatment; and the determination whether the alternative will comply with the statutory preference for treatment.

Short-Term Effectiveness

Short-term effectiveness refers to the effects an alternative may have during construction and implementation phases until the cleanup objectives have been achieved. Alternatives will be evaluated to determine the effects on human health and the environment during implementation. Each alternative will be assessed against the following factors: protection of the community and workers during the remedial action environmental impacts and the time required to achieve the remedial action objectives.

Implementability

This criterion assesses the technical and administrative feasibility of implementing an alternative, and the availability of necessary services and materials. The following factors will be analyzed during the implementability assessment: the technical feasibility of construction and operation; the reliability of the technology; the practicability of employing additional remedial actions; the ability to monitor the effectiveness of the remedial action; administrative coordination with other offices and agencies; the availability of adequate offsite hazardous (or mixed) waste treatment, storage, and disposal; and the availability of equipment, expertise, and other services and materials.

Costs

A cost estimate will be prepared and, if necessary, a cost-sensitivity analysis will be prepared to evaluate costing assumptions. Capital costs include direct construction costs, indirect non-construction costs, and overhead costs. Operating and maintenance costs are incurred after construction in order to operate the remedial action on a continuous basis until the remedial action objectives have been achieved. FS cost estimates are expected to be within an accuracy range of minus 30 percent to plus 50 percent. If this accuracy cannot be achieved, the fact (with supporting documentation) will be stated in the FS report.

A costs-sensitivity analysis may be conducted to determine the effect that specific cost assumptions have on the total estimated cost of an alternative. The cost assumptions will be based on site-specific data, technological operating data, etc., although the assumptions will be subject to varying degrees of uncertainty, depending on the accuracy of the data.

State Acceptance

This criterion addresses the state's administrative and technical issues and concerns with each of the alternatives.

Community Acceptance

The community acceptance program addresses the public's concerns and issues with each of the alternatives.

6.3 TASK 11 - FEASIBILITY STUDY REPORT

The FS report will contain a narrative discussion of each alternative's evaluation against the nine criteria listed above. As with the RI report, the FS report will address both the alluvial and bedrock components of the site. There is a potential for different alternatives to be considered for the bedrock than for the uppermost aquifer. The narrative will describe how each alternative addresses the technical treatability issues, long-term and short-term effectiveness, costs, protection of human health and the environment, compliance with ARARs, etc. Once the alternatives have been described, a comparative analysis will be conducted to evaluate the relative performance of each alternative. The relative advantages and disadvantages of each alternative with respect to the other alternatives will be determined in order to assess the key tradeoffs that must be made in selecting a remedial action. A candidate alternative must generally attain the primary objectives of compliance with ARARs and overall protection of human health and the environment in order for it to be eligible for selection as the remedial action. A narrative discussion of the alternatives comparison describing the tradeoffs, benefits, and shortcomings of each alternative in comparison to the others will be included in the FS report.

Following completion of the FS process, the results of the detailed alternatives comparison and risk management will be used as the rationale for selecting a preferred alternative and a remedial action. Although the purpose of the FS report and process is not to select a remedial action, it will present and evaluate the alternatives in sufficient detail in order to objectively consider all significant issues and select a feasible, cost-effective, and defensible remedial action.

The FS Report will present a description of the feasibility study and its results. The report will include sections describing: site background; nature and extent of problem; summary results of the RI; risk assessment and environmental evaluation; identification, screening, and detailed evaluation of remedial alternatives; and the recommended remedial actions. This task includes development of a Draft FS, a revised Draft FS that incorporates EPA and CDH comments, and preparation of a Final FS that incorporates public comments.

As with the RFI/RI, some portions of the CMS/FS may be conducted separately for the bedrock and alluvial components of the site. It is likely that remediation requirements will not be the same for the bedrock as for the upper hydrostratigraphic unit (HSU). However, both the bedrock and alluvium will be addressed during the CMS/FS and only one CMS/FS report will be prepared.

7.0
SCHEDULE

The schedule for conducting the Phase II RFI/RIFS is summarized in Figure 7-1. The schedule includes both the alluvial and bedrock components of the RFI/RI and the Corrective Measures Study/Feasibility Study (CMS/FS) activities. Dates are not shown since the IAG had not yet been signed at the time this work plan was prepared. However, at the time of work plan preparation, the schedule was in accordance with recent drafts of the IAG schedule.

As discussed in Section 8.0, Field Sampling Plan, the RFI/RI for bedrock characterization will be conducted in steps. After the initial round of borings and wells, sample analysis and data validation will be conducted, followed by interim data evaluation. A second round of field investigation will be conducted to further characterize the site, if necessary, and to satisfy data needs and data quality objectives for the CMS/FS. After the second round of field investigation, there will be further sample analysis and data validation, data evaluation and preparation of the draft and final RFI/RI reports.

During RFI/RI report preparation, on-going treatability studies will be in progress and the CMS/FS will start. The CMS/FS will include remedial alternatives development and screening, and detailed analysis of alternatives. According to this schedule, nearly 4 years will elapse from the time this work plan is finalized until the final CMS/FS report is issued.

8.1 BACKGROUND

The objectives of the bedrock component of the Phase II RFI/RI are to sufficiently characterize the bedrock to support the baseline risk assessment and, if significant contamination is found, to sufficiently characterize the nature and extent of bedrock contamination to support the feasibility study, further risk assessment, and, if necessary, remedial design. Within these broad objectives, site-specific data needs have been identified in Section 4.0. The purpose of this section of the work plan is to provide a Field Sampling Plan (FSP) that will address these data needs and describe the work required to fulfill the data quality objectives (DQOs).

The Phase II RFI/RI for Operable Unit 2 has been divided into an alluvial component and a bedrock component. The alluvial component, described in a previously prepared work plan (EG&G 1990c), is subdivided into two steps. The first step will consist of a contaminant plume delineation study that will collect the data necessary to evaluate the need for an Interim Measure/Interim Remedial Action (IM/IRA) addressing contaminated groundwater in the upper hydrostratigraphic unit (HSU) at Operable Unit 2. This will include characterization of the nature and extent of contamination in the upper HSU and the hydraulic interconnection between the upper HSU and the upper bedrock. The second step of the alluvial component of the RFI/RI will be characterization of the source areas in Operable Unit 2.

A stepped approach will also be used for the bedrock component of the RFI/RI. As presented in Subsection 2.3, Site Conceptual Model, and discussed further in Section 4.0, Data Needs and Data Quality Objectives, there are believed to be three potential sources of contamination of the bedrock: (1) plumes of dissolved (aqueous phase) contaminants in the upper HSU, (2) pools or pockets of non-aqueous phase liquid contaminants near the bottom of the upper HSU, and (3) unidentified off-site sources located topographically and/or hydraulically upgradient of the site.

Except for the potential off-site sources, the alluvial component RFI/RI field work will characterize the nature and extent of potential sources of bedrock contamination. As a result of the limited information available on both physical characterization and characterization of nature and extent of contamination in the bedrock, a stepped approach will be used to implement the bedrock component of the RFI/RI. This approach will involve a continuing reassessment of the conditions as data are obtained so the sampling efforts can be appropriately redirected. This FSP establishes the criteria that will be used to redirect the sampling efforts, as necessary, to accomplish the stated goals.

The sampling activities to characterize the bedrock will involve drilling boreholes and installing groundwater monitoring wells. As discussed in more detail in Subsection 8.2, 20 locations have been preliminarily

identified for clusters of boreholes and wells for the initial step of the investigation. The 20 clusters contain a total of 20 boreholes and 38 wells. The locations of the clusters, the depths of the boreholes, and the number of wells and their depths are subject to revision based on the results of the alluvial component of the RFI/RI and based on volatile organic screening that is conducted while drilling the boreholes during the bedrock component of the RFI/RI. Therefore, the initial step of the bedrock field sampling outlined in Section 8.2 is intended to demonstrate the rationale and general level of effort that will be required during the first step. The level of effort required for subsequent investigation will depend to a large degree on the results of the initial step. For example, significantly greater effort would be needed to define the extent of plumes identified in the bedrock and obtain sufficient data for evaluating remedial actions than would be required if no contamination is found in the bedrock during the initial investigation.

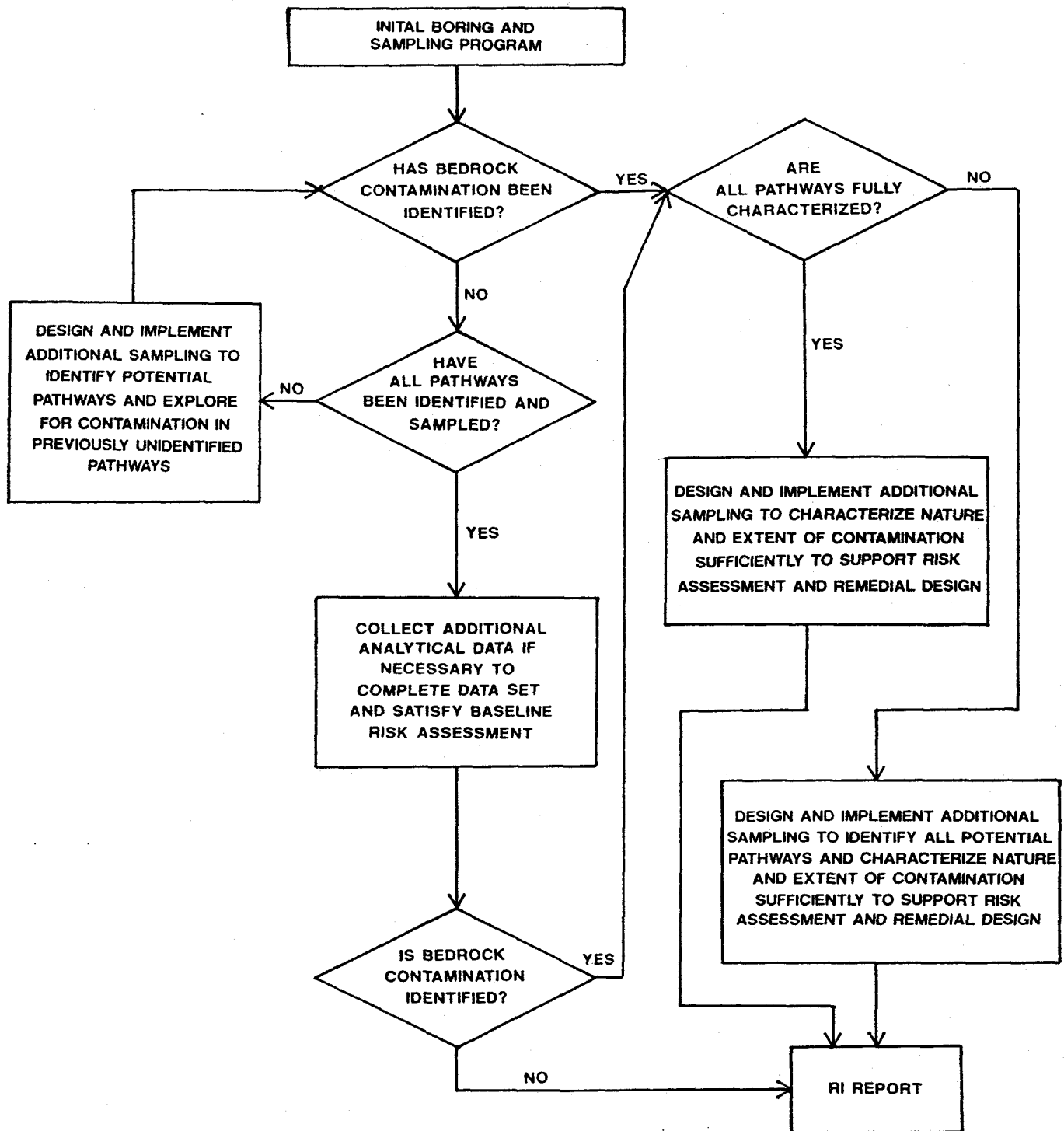
All sampling and analysis activities will be conducted according to the project Health and Safety Plan (HSP) and the Sample Analysis Plan (SAP). The SAP will include the Standard Operating Procedures (SOP) and the Quality Assurance Project Plan (QAPjP), which were under development at the time this work plan is being prepared.

8.2 FIELD SAMPLING

8.2.1 Sampling Rationale

Figure 8-1 shows the locations of 20 proposed well/borehole clusters that have been identified as preliminary locations for the initial investigation. After this first round of drilling and sampling, there is a potential for the working hydrogeologic site model to be revised. In addition, the initial investigation will indicate either that significant bedrock contamination exists or that it appears not to. The scope of subsequent steps of the investigation will depend on the results of the initial investigation.

Figure 8-2 presents a flow diagram demonstrating the scope and sequencing of subsequent steps of the investigation that will be required depending on the interim results obtained after the initial boring and sampling. If bedrock contamination is not identified initially, subsequent steps will consist of demonstrating that potential pathways have been sufficiently characterized to conclude that contamination does not exist along any potential pathway, and to provide a sufficient data set for the baseline risk assessment. Similarly, if, at any time during the investigation, bedrock contamination is identified, subsequent sampling will be designed to further characterize potential migration pathways and the nature and extent of contamination along each pathway to support risk assessment and remedial design. After each significant step of the investigation, the requirements for further sampling will be established based on the rationale presented in this Field Sampling Plan. Each step of the work may be redirected based on interim results of ongoing evaluation of the data. Geologic and chemistry data will be evaluated as it is obtained. EG&G will direct the continuous updating of the hydrogeologic site model throughout the investigation.



DRAFT

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

**SCOPE AND SEQUENCING
OF BEDROCK RFI/RI STEPS**

The physical properties and contamination of the bedrock immediately beneath and downgradient of the potential bedrock source areas identified during the alluvial RI will be characterized by laboratory physical and chemical analysis of bedrock samples and by chemical analysis of groundwater obtained from wells installed in the intervals of interest. Characterization of unweathered bedrock chemistry will be based solely on groundwater chemistry testing. Selection of well screen intervals will consider the results of screening samples of the weathered and unweathered bedrock by head space techniques using a portable gas chromatograph (GC).

Only limited hydraulic conductivity information is currently available for the bedrock, and the results of packer tests conducted during the Phase I RI do not indicate a significant difference in hydraulic conductivity between the unweathered sandstone and the claystone. However, geologic interpretation indicates the lower channel sandstones may control the groundwater flow regime in the lower HSU(s). All of the hydraulic conductivity values measured in the unweathered bedrock were relatively low, on the order of 1×10^{-6} to 1×10^{-8} cm/sec. Hydraulic conductivity measurements performed in the different lithologic units will, therefore, be an important part of characterizing the bedrock hydrogeology. Packer tests will be conducted in rock-cored sections of the central borehole at each cluster location and slug tests will be conducted in all wells. The packer testing program will concentrate on distinguishing the hydraulic conductivities of the unweathered claystones and siltstones from those of the unweathered sandstones. Slug test results will be used to distinguish hydraulic conductivity of unweathered claystone from that of weathered claystone. However, slug tests may be unsuccessful if small saturated thicknesses (i.e., less than about 3 feet) are found. Initially, conventional pump-out aquifer tests will not be conducted in the claystone and lower sandstones because the wells are not expected to yield sufficient quantities of water to make this a practical method. Hydraulic head and hydraulic conductivity data will be used to develop potentiometric surface maps and/or flow nets for the various lithologic intervals.

8.2.2 Boreholes

Location and depth criteria for boreholes are presented in Table 8-1. There is a potential for the locations of boreholes and wells to be offset based on the results of the alluvial component of the RFI/RI and, in some cases, several offset locations may be required to explore for the location of subcropping sandstones. Typically, the boreholes will be relatively deep, on the order of 100 to 300 feet; however, there are several shallower boreholes proposed toward the bottom of the hillside to the southeast of the 903 Pad area. Ten of the boreholes will penetrate the Arapahoe Formation Sandstone No. 5 interval, three will fully penetrate the Arapahoe Formation, and the remaining seven boreholes will terminate at shallower depths.

Lithology of all boreholes, including holes drilled for wells, will be logged the entire depth in accordance with SOP Number 3.1, Logging Alluvial and Bedrock Material. Logging will be based on continuous lithologic sampling of the boreholes. Sampling soils above the bedrock will be conducted using hollow-stem auger

TABLE 8-1

**PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2**

Cluster Number (Approx. Elevation-ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft. below ground)
1 (5950)	B1	Located in the northwest portion of the East Trenches in an area of high concentrations of volatile organic contamination in the upper HSU (alluvium and SS#1). Evaluate vertical gradients. Define stratigraphy at the four wells in the cluster, evaluate bedrock contamination beneath source area, and evaluate lateral extent of various sandstone intervals.	Approximately 150 (penetrate SS#5 interval)	
	W1	Evaluate groundwater quality in weathered claystone (if present) immediately beneath SS#1.	70	60-70
	W2	Evaluate groundwater quality in unweathered bedrock above first sandstone encountered beneath SS#1.	105	95-105
	W3	Evaluate groundwater quality in first sandstone encountered beneath SS#1.	135	120-135
	W4	Evaluate groundwater quality in claystone beneath sandstone screened by W3.	145	135-145

TABLE 8-1

PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)

Cluster Number (Approx. Elevation-ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft. below ground)	Anticipated Screened Interval (ft. below ground)
2 (5068)	B2	Located in Mound Area between two existing wells (1887 and 2087) where volatile organic contamination has tentatively been detected in SS#3 and SS#4. Additional information will be obtained on lateral extent of SS#3 and SS#4. Evaluate vertical gradients, define stratigraphy at wells in cluster and evaluate lateral extent of SS#3 and SS#4.	Approximately 145 (penetrate SS#5 interval)	
	W5	Evaluate groundwater quality in weathered bedrock immediately beneath alluvial soils (or beneath SS#1 if encountered).	35	25-35
	W6	Evaluate groundwater quality in uppermost unweathered claystone.	70	60-70
	W7	Evaluate groundwater quality in SS#3, if present.	115	105-115
	W8	Evaluate groundwater quality in SS#4, if present.	135	125-135

TABLE 8-1

**PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)**

Cluster Number (Approx. Elevation-ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft. below ground)
3 (5972)	B3	Located in south-central portion of Mound Area. Offset as necessary to locate in low area of SS#1 if detected during alluvial RFI/RI field work. Evaluate vertical gradients. Evaluate stratigraphy at wells in cluster and lateral extent of lower sandstones.	Approximately 140 (penetrate SS#5 interval)	
	W9	Evaluate groundwater quality in weathered claystone (if present) immediately beneath SS#1.	45	35-45
	W10	Evaluate groundwater quality in uppermost unweathered claystone.	80	70-80

TABLE 8-1

**PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)**

Cluster Number (Approx. Elevation-ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft. below ground)
4 (5982)	B4	Located at upgradient end of Operable Unit 2 to evaluate upgradient groundwater quality and entire depth of Arapahoe Formation stratigraphy for use in site-wide geologic characterization. Will be offset as necessary to locate in low area of SS#1 if detected during alluvial RI field work.	Approximately 280 (penetrate basal Arapahoe sandstone and confirm Laramie Formation)	
		Define stratigraphy at all wells in cluster and evaluate soil/bedrock contamination at upgradient end of Operable Unit 2. Data will supplement on-going site-wide geologic characterization.		
	W11	Evaluate upgradient groundwater quality in weathered claystone (if present) immediately beneath SS#1.	45	35-45
	W12	Evaluate upgradient groundwater quality in uppermost unweathered claystone.	60	50-60
	W13	Evaluate upgradient groundwater quality and hydraulic heads in SS#2, SS#3 and SS#4, if encountered.	85	75-85
	W14		110	100-110
	W15		130	120-130

TABLE 8-1

**PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)**

Cluster Number (Approx. Elevation-ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft. below ground)	Anticipated Screened Interval (ft. below ground)
5 (5972)	B5	Located near southeast corner of 903 Pad. Evaluate contamination of soil/bedrock in 903 Pad source area. Use well cluster to evaluate vertical and horizontal gradients in lower sandstones potentially subcropping in hillside to south.	Approximately 145 (penetrate SS#5 interval)	
	W16	Evaluate groundwater quality in uppermost weathered bedrock (or immediately beneath SS#1 if encountered).	35	25-35
	W17	Evaluate groundwater quality and hydraulic heads in SS#2, SS#3, SS#4 and SS#5, if encountered.	80	70-80
	W18		110	100-110
	W19		130	120-130
	W20		145	135-145

TABLE 8-1

**PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)**

Cluster Number (Approx. Elevation-ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft. below ground)
6 (5961)	B6	Located approximately 300 feet south of southwest corner of East Trenches Area. Offset as necessary to locate in low area of SS#1 if found during alluvial field work. Evaluate vertical gradients and horizontal gradients in lower sandstones. Evaluate stratigraphy at wells in cluster and lateral extent of lower sandstones.	Approximately 140 (penetrate SS#5 interval)	
	W21	Evaluate groundwater quality in weathered claystone (if present) immediately beneath SS#1.	55	45-55
	W22	Evaluate groundwater quality in uppermost unweathered claystone.	85	75-85
	W23 W24	Evaluate groundwater quality and hydraulic heads in both SS#3 and SS#4, if present.	110 130	100-110 120-130
7 (5955)	B7	Located just south of central portion of East Trenches Area. Evaluate lateral extent of SS#4 and hydraulic heads/gradients in it if encountered. Also evaluate stratigraphy at wells in cluster and vertical gradients.	Approximately 140 (penetrate SS#4 interval)	
	W25	Evaluate groundwater quality in unweathered claystone.	35	25-35
	W26	Evaluate groundwater quality and hydraulic heads in SS#4, if encountered.	140	130-140

TABLE 8-1

**PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)**

Cluster Number (Approx. Elevation-ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft. below ground)
8 (5925)	B8	Located approximately 500 feet south of central portion of East Trenches Area. Evaluate lateral extent of lower sandstones for potential pathway evaluation. Do not install wells initially.	Approximately 115 (penetrate SS#5)	
9 (5943)	B9	Located in eastern portion of East Trenches Area between two existing wells where low levels of volatile organic contaminants have tentatively been detected in claystone at approximate depth of SS#2 interval. Evaluate soil/bedrock contamination and evaluate vertical gradients.	Approximately 120 (20 feet below bottom of SS#2 interval)	
	W27	Evaluate groundwater quality in uppermost weathered bedrock (or immediately beneath SS#1 if encountered).	55	45-55
	W28	Evaluate groundwater quality in claystone at depth of SS#2 interval, or in SS#2 if encountered.	100	90-100
10 (5920)	B10	Located approximately 700 feet northeast of northeast corner of East Trenches Area. Evaluate entire depth of Arapahoe Formation stratigraphy for use in evaluating potential pathways and for site-wide geologic characterization. Do not install wells initially.	Approximately 280 (penetrate basal Arapahoe Sandstone and confirm Laramie Formation)	

TABLE 8-1

**PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)**

Cluster Number (Approx. Elevation-ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft. below ground)	Anticipated Screened Interval (ft. below ground)
11 (5945)	B11	Located on hillside south of 903 Pad Area in area of potentially subcropping SS#2 and confined SS#5. Evaluate potential for contaminated groundwater in upper HSU to enter SS#2. Evaluate vertical gradient between SS#2 and SS#5 intervals, and horizontal gradients within SS#2. Additional Well in SS#2 required if Cluster 11 appears not to be hydraulically connected to SS#2 well at Cluster 5. Several offset borehole locations may be required to confirm presence/absence of subcrop.	Approximately 100 (penetrate SS#5 interval)	
	W29	Evaluate groundwater quality and hydraulic head in SS#2.	30	20-30
	W30	Evaluate groundwater quality and hydraulic head in SS#5.	100	90-100
12 (5895)	B12	Located on hillside south of 903 Pad Area in area of potentially subcropping SS#3. Evaluate potential for contaminated groundwater in upper HSU to enter SS#3. Evaluate horizontal gradient in SS#3 by comparing with Cluster 5. Additional nearby well may be required if Cluster 12 appears not to be hydraulically connected to SS#3 at Cluster 5. Several offset borehole locations may be required to confirm presence/absence of subcrop.	Approximately 35 (penetrate SS#3)	
	W31	Evaluate groundwater quality and hydraulic head in SS#3.	35	25-35

TABLE 8-1

**PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)**

Cluster Number (Approx. Elevation-ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft. below ground)
13 (5920)	B13	Located on hillside south of 903 Pad Area in area of potentially subcropping SS#2. Evaluate potential for contaminated groundwater in upper HSU to enter SS#2. Evaluate horizontal gradient in SS#2 by comparing with Cluster 5. Additional nearby well may be required if Cluster 12 appears not to be hydraulically connected to SS#2 at Cluster 5. Several offset borehole locations may be required to confirm presence/absence of subcrop.	Approximately 25 (penetrate SS#2)	
	W32	Evaluate groundwater quality and hydraulic head in SS#2.	25	15-25
14 (5865)	B14	Located on hillside southeast of 903 Pad Area in area of potentially subcropping SS#4. Evaluate potential for contaminated groundwater in upper HSU to enter SS#4. Evaluate horizontal gradient in SS#4 by comparing with Clusters 5, 6 and 7. If there is insufficient hydraulic connection with these other clusters, an additional nearby well will be required. Several offset borehole locations may be required to confirm presence/absence of subcrop.	Approximately 25 (penetrate SS#4 interval)	
	W33	Evaluate groundwater quality and hydraulic head in SS#4.	25	15-25
15 (5815)	B15	Located east of 903 Pad Area near center of sandstone channel identified by high-resolution seismic profiling. Evaluate stratigraphy to provide control for seismic work.	Approximately 200 (penetrate basal Arapahoe Sandstone and confirm Laramie Formation)	
16 (5925)	B16	Located just southeast of 903 Pad Area near center of sandstone channel identified by high-resolution seismic profiling. Evaluate stratigraphy to provide control for seismic work.	Approximately 100 (penetrate SS#5 interval)	

TABLE 8-1

**PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)**

Cluster Number (Approx. Elevation-ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft. below ground)	Anticipated Screened Interval (ft. below ground)
17 (5920)	B17	Located just north of central portion of East Trenches Area. Evaluate vertical gradients and horizontal gradients in lower sandstones, if found.	Approximately 110 (penetrate SS#5 interval)	
	W34	Evaluate groundwater quality in weathered claystone (if present).	45	35-45
	W35	Evaluate groundwater quality in uppermost unweathered claystone.	65	55-65
	W36	Evaluate groundwater quality and hydraulic head in SS#3 for SS#4, whichever is shallower, if encountered.	80	70-80
18 (5972)	B18	Located at east end of Mound Area. Determine presence or absence of SS#3 and SS#4 for pathway evaluation.	Approximately 135 (penetrate SS#4)	
	W37 W38	Evaluate upgradient groundwater quality in SS#3 and SS#4 if encountered.	120 135	110-120 125-135
19 (5959)	B19	Located adjacent to Well 22-74 just south of east portion of East Trenches Area. Evaluate lithology penetrated by Well 22-74 to evaluate it as a potential pathway. Install additional wells only if contamination is indicated by GC headspace screening.	180	
	B20	Located east of northeast corner of 903 Pad. Evaluate extent of SS#3 and SS#4 for pathway evaluation. Install wells only if contamination is indicated by GC headspace screening.	Approximately 145 (penetrate SS#5 interval)	140-145
TOTALS				
			20 Boreholes - 2,710 lineal feet	
			38 Wells - 3,235 lineal feet	

continuous coring techniques. Once bedrock is encountered, grouted casing will be embedded into the bedrock to isolate the alluvium from the bedrock prior to further drilling (SOP Number 3.3, Isolating Bedrock from Alluvium with Grouted Surface Casing). The referenced SOP requires that the surface casing embedment be 2 feet into the weathered bedrock. However, the intent is to place the bottom of the casing approximately 2 feet below the interface describing a substantial reduction in hydraulic conductivity. If the uppermost weathered bedrock is highly weathered and/or fractured, this embedment depth will be adjusted downward. A conservative approach will be used early in the program with casing embedment on the order of 5 feet. The project hydrogeologist responsible for the on-going hydrogeologic site characterization will be responsible for establishing and documenting protocols for surface casing embedment after the first several boreholes are completed and evaluated.

Weathered bedrock will also be drilled and sampled using hollow-stem auger continuous coring techniques. Hollow stem auger continuous core runs will be 2 feet long in the alluvium and weathered bedrock. Once the weathered bedrock has been fully penetrated, NX rock core sampling techniques with carbide or diamond bits using potable water from an approved source as the drilling fluid will be used for the remainder of the borehole. NX core runs will not exceed 5 feet in length.

From the 2-foot long continuous soil and weathered rock samples, discrete samples will be submitted for laboratory chemical analysis at 2-foot increments for volatile organic analysis. Other chemical analyses will be conducted on samples composited from the remaining material from two sequential 2-foot samples (see SOP Number 3.2, Drilling and Sampling Using Hollow Stem Auger Techniques). Collection of samples for chemical analysis will start approximately 5 feet above bedrock (estimated based on Phase I RI and Phase II alluvial RFI/RI results) and continue to the base of the weathered bedrock. The borehole/well cluster locations were generally not located to search for small depressions where dense non-aqueous phase liquids may collect. However, during drilling, samples of weathered and unweathered bedrock will be screened by headspace methods using a portable gas chromatograph (GC) at 2-foot increments (SOP No. 3.9, Soil Gas Sampling and Field Analysis). The headspace samples will be collected and placed in jars from each 2-foot long auger core sample in weathered rock and from each 5-foot long NX core sample obtained in unweathered rock. High concentrations detected by the GC headspace analyses could potentially indicate the presence of non-aqueous phases of contaminants. Sample collection and preparation is discussed in more detail in SOPA 10.2 in Section 10.0.

Borehole hydraulic conductivity tests (pump-in packer tests) will be conducted the entire depth of the NX-cored unweathered bedrock within the central borehole at each cluster. Packer tests will be conducted at intervals not exceeding 10 feet using a single packer arrangement after each segment of hole is advanced. Packer test procedures are given in SOP Number 2.3, Pump-in Borehole Packer Testing.

The physical characteristics of the weathered and unweathered bedrock will be evaluated based on standard material properties, such as grain size distribution and Atterberg limits. Laboratory hydraulic conductivity

tests will be conducted on at least two samples of sandstone from each lithologic interval of the lower sandstones (i.e, Arapahoe Formation Sandstone Nos. 2, 3, 4, and 5). Similarly, laboratory hydraulic conductivity tests will be conducted on at least eight samples each of weathered claystone and unweathered claystone. Selection of samples for testing will be made by the project hydrogeologist responsible for the ongoing geohydrologic site characterization. The laboratory hydraulic conductivity tests will generally be conducted to measure vertical hydraulic conductivity; however, at the project hydrogeologist's discretion, horizontal tests should also be conducted if it appears that they can be successfully completed with the available samples.

The central borehole at each cluster will be logged geophysically from the base of the cased-off alluvium to the bottom of the hole in order to obtain additional stratigraphic information. Stratigraphic correlation between geophysical logs will aid the interpretation of the geologic extent of identified units. Sonic log data will assist the integration of the existing seismic data with the ongoing geologic characterization program.

Borehole geophysical logging will be conducted immediately after drilling and sampling activities have been completed and before the hole is cased or abandoned. Only water will be added to boreholes for the purpose of geophysical logging. If borehole conditions require the addition of weighting materials, approval will be requested from the project manager or project hydrogeologist. Geophysical logging should consist of a full suite of downhole logs, including:

- Temperature
- Fluid Resistivity
- Spontaneous Potential
- Resistivity 16" + 64"
- Induction
- Gamma Gamma Density
- Neutron
- Natural Gamma Ray
- Sonic log (full wave form)
- Caliper log

Boreholes that are not designated for subsequent well installation will typically be abandoned immediately after completion. However, in some instances, if it can be demonstrated that completing a borehole as a well will not increase the chances of cross-contamination, wells may be completed in boreholes after overdrilling to the appropriate diameter. This determination may be made if there are previous data (including GC headspace screening in that borehole) indicating there are no potentially contaminated zones of bedrock between the bottom of the upper HSU and the screened-interval, or if nested surface casings have been provided to isolate the screened interval from overlying potentially contaminated zones of bedrock.

If the bottom of the well screen interval is not at the bottom of the borehole, the portion of the borehole below the screen will be properly grouted prior to well construction. Well screens will not be placed in zones that have been packer tested. If a well is completed at the bottom of a borehole, hydraulic conductivity will be evaluated by means of a pump-out or bail-down recovery test. If not completed as wells, abandonment of boreholes will be conducted in accordance with SOP Number 3.5, Plugging and Abandonment of Boreholes.

8.2.3 Groundwater Monitoring Wells

The initial investigation outlined in Table 8-1 will involve installing two-inch diameter groundwater monitoring wells. Unless otherwise directed by the project hydrogeologist, wells will be constructed within 15 feet of the central borehole at each cluster. For planning purposes, 38 wells are anticipated during the initial investigation; however, the installation of a number of these wells will be contingent upon whether certain intervals of sandstone are found at some of the cluster locations. In other words, a well targeted for a particular sandstone interval may not be constructed if sandstone is not found at that depth interval in the borehole, unless the project hydrogeologist determines a well at that location and depth would be beneficial. Depth criteria for anticipated screened intervals are presented in Table 8-1. Wells will be developed according to SOP No. 2.2, Well Development.

Wells that are scheduled to be screened in sandstone will be screened in the interval indicated in Table 8-1 if that lithology is encountered in the borehole made for the well. However, screen intervals for wells in both weathered and unweathered claystone may depend on the degree of weathering or fracturing observed in the core and/or on the results of field headspace screening by GC during the borehole drilling. At locations where high concentrations of volatile organic compounds are found near the bottom of the uppermost unconfined aquifer during the Phase II alluvial RFI/RI, the potential presence of high concentrations in the underlying bedrock will be explored by field GC headspace measurements. If the headspace measurements indicate relatively high concentrations of volatile organic compounds in the weathered bedrock, the well will be screened to bracket the zone of high contaminant levels so the wells can be used to check for the presence of dense non-aqueous phase liquids. Similarly, in zones of unweathered claystone between the uppermost aquifer and underlying lower sandstones, or between intervals of lower sandstones, the placement of well screen intervals will consider the results of screening using GC headspace methods. Zones of apparent contamination will be preferred for screen intervals. If GC screening does not indicate contamination, the field hydrogeologist designated to supervise well installation and logging may select the screened interval based on the amount of weathering or fracturing observed and assumed to represent potential secondary hydraulic conductivity. Relatively weathered or fractured zones will be preferred for well screen intervals. Otherwise, the screened sections will be placed mid-depth between the overlying and underlying sandstone intervals. The screened interval of wells isolated in claystone will be 10 feet in length.

The bedrock will be isolated from potential contamination by groundwater from the upper HSU using grouted casing. Similarly, if there are data indicating that zones of contaminated bedrock will be penetrated during the construction of wells screened beneath those contaminated zones, additional nested surface casings will be provided to isolate the screened interval of the wells from the overlying potential contamination. Such data will consist either of previous groundwater chemistry data or GC headspace screening on borehole samples of bedrock.

The RFI/RI will be based on at least one round of groundwater chemistry analysis from each well. However, there is a potential for more rounds of data to be available for some of the earlier wells. Groundwater measurements and sampling will be conducted according to SOP No. 2.1, water level measurements in wells and piezometers, SOP No. 2.5, Measurement for Groundwater Field Parameters, and SOP No. 2.6, Groundwater Sampling. Water level measurements will be obtained monthly throughout the field investigation. During groundwater sampling, an interface probe will be used to check for the presence of low and high density non-aqueous phase liquids in wells where the GC headspace screening indicates they may be present. If they are detected, a discrete sampler will be used to sample them before purging the well for water samples. Detailed procedures are presented in SOPA Number 10.1 in Section 10.0.

There is a potential for some wells, primarily those completed in claystone, to produce water slowly enough that they can not be sampled using conventional methods (i.e., purging prior to sampling). In these wells, two alternatives will be used to obtain samples:

- (1) In weathered claystone where the alluvial RFI/RI results indicate relatively high concentrations of volatile organic compounds (i.e., greater than about 1% of the saturation concentration in water), or where GC headspace readings indicate similar concentrations, a conventional well will be installed to check for non-aqueous phase liquids. Sampling will be conducted by purging 1 borehole volume and obtaining the sample as soon as possible.
- (2) In weathered and unweathered claystone where there do not appear to be relatively high concentrations of volatile or semivolatile organic compounds, a conventional well will not be installed, but rather an electronic or pneumatic piezometer tip and a porous stone-type isolated sampler (e.g., BAT system sampler) will be installed in the uncased bottom of the borehole. Prior to installation, a casing will be grouted into place to a depth 3 to 5 feet above the bottom of the hole. The uncased bottom of the hole will be developed by removing all drilling fluids and residues and then removing all water that collects in the hole during a 2-week period, or a maximum of 5 well volumes. After development, the piezometer and sampler will be installed.

8.2.4 Location Surveying

Locations of all boreholes and wells will be surveyed to within an accuracy of one foot before drilling or sampling. After drilling, all wells and borings will be resurveyed. Horizontal accuracy will be ± 0.1 foot for boreholes and wells. Vertical accuracy will be ± 0.1 foot for boreholes and 0.01 foot for wells. Three elevations will be determined for each well: ground surface, top of well casing, and top of surface casing. Locations are based on State Planar reference and elevations are feet above mean sea level (USGS datum).

8.2.5 Data Reporting Requirements

Field data will be input into the RFEDS environmental database using a remote data entry module supplied by EG&G. Data will be entered on a timely basis and a 3.5-inch diskette will be delivered to EG&G. A hard copy report will be generated from the module for contractor use. The data will be put through a prescribed QC process based on a SOPA to be generated by EG&G.

A sample tracking spreadsheet will be maintained by the contractor for use in tracking sample collection and shipment. EG&G will supply the spreadsheet format and will stipulate the timely reporting of the information. This data will also be delivered to EG&G on a 3.5-inch diskette.

Computer hardware and software requirements for contractors using government-supplied equipment will be supplied by EG&G. Computer and data security will also follow acceptable procedures outlined by EG&G.

8.3 SAMPLE ANALYSIS

8.3.1 Soil Samples from Boreholes

8.3.1.1 Chemical Analysis

Soil samples will be collected for chemical analysis from soil and weathered bedrock, as discussed in Subsections 8.1 and 8.2. Designated samples will be analyzed for the chemical parameters listed in Table 8-2 in accordance with the General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G 1990f).

8.3.1.2 Headspace Analysis

Samples of unweathered bedrock will be collected from each of the boreholes for headspace analyses for volatile organic compounds (VOCs). Analysis of samples will be performed using a portable gas chromatograph (GC) to detect the presence of trichloroethylene (TCE), tetrachloroethylene (PCE), carbon

TABLE 8-2

PHASE II RFI/RI
SOIL, BEDROCK, AND GROUNDWATER SAMPLING
ANALYTES AND COMPOUNDS
OPERABLE UNIT 2

METALS

Target Analyte List - Soil and Bedrock

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

Other Metals

Molybdenum
Cesium
Strontium
Lithium
Tin

Target Analyte List - Groundwater

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

Other Metals

Molybdenum
Cesium
Strontium
Lithium
Tin

TABLE 8-2

PHASE II RFI/RI
SOIL, BEDROCK, AND GROUNDWATER SAMPLING
ANALYTES AND COMPOUNDS
OPERABLE UNIT 2
(Continued)

OTHER INORGANICS - Soil and Bedrock

pH
Nitrate
Percent Solids
Cyanide
Moisture Content

FIELD PARAMETERS - Groundwater

pH
Specific Conductance
Temperature

INDICATORS - Groundwater

Total Dissolved Solids

ANIONS - Groundwater

Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate as N
Cyanide

DISSOLVED RADIONUCLIDES - Soil and
Bedrock

Gross Alpha
Gross Beta
Uranium 233+234,235 and 238
Americium 241
Plutonium 239+240
Tritium
Strontium 90, 89
Cesium 137

DISSOLVED RADIONUCLIDES - Groundwater

Gross Alpha
Gross Beta
Uranium 233+234,235 and 238
Americium 241
Plutonium 239+240
Tritium
Strontium 90
Cesium 137
Radium 226, 228

TABLE 8-2

PHASE II RFI/RI
SOIL, BEDROCK, AND GROUNDWATER SAMPLING
ANALYTES AND COMPOUNDS
OPERABLE UNIT 2
(Continued)

ORGANICS: VOLATILES

Target Compound List - Soil and
Bedrock

Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethene
1,1-Dichloroethane
total 1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane
Carbon tetrachloride
Vinyl Acetate
Bromodichloromethane
1,1,2,2-Tetrachloroethane
1,2-Dichloropropane
trans-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
cis-1,3-Dichloropropene
Bromoform
2-Hexanone
4-Methyl-2-pentanone
Tetrachloroethene
Toluene
Chlorobenzene
Ethyl Benzene
Styrene
Total Xylenes

Target Compound List - Groundwater

Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethene
1,1-Dichloroethane
total 1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane
Carbon tetrachloride
Vinyl Acetate
Bromodichloromethane
1,1,2,2-Tetrachloroethane
1,2-Dichloropropane
trans-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
cis-1,3-Dichloropropene
Bromoform
2-Hexanone
4-Methyl-2-pentanone
Tetrachloroethene
Toluene
Chlorobenzene
Ethyl Benzene
Styrene
Total Xylenes

TABLE 8-2

**PHASE II RFI/RI
SOIL, BEDROCK, AND GROUNDWATER SAMPLING
ANALYTES AND COMPOUNDS
OPERABLE UNIT 2
(Continued)**

ORGANICS: SEMI-VOLATILES

Target Compound List - Soil and
Bedrock

Phenol
bis(2-Chloroethyl)ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl Alcohol
1,2-Dichlorobenzene
2-Methylphenol
bis(2-Chloroisopropyl)ether
4-Methylphenol
N-Nitroso-Dipropylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
Benzoic Acid
bis(2-Chloroethoxy)methane
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
Hexachlorobutadiene
4-Chloro-3-methylphenol
(para-chloro-meta-cresol)
2-Methylnaphthalene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronaphthalene
2-Nitroaniline
Dimethylphthalate
Acenaphthylene
3-Nitroaniline
Acenaphthene

Target Compound List - Groundwater

Phenol
bis(2-Chloroethyl)ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl Alcohol
1,2-Dichlorobenzene
2-Methylphenol
bis(2-Chloroisopropyl)ether
4-Methylphenol
N-Nitroso-Dipropylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
Benzoic Acid
bis(2-Chloroethoxy)methane
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
Hexachlorobutadiene
4-Chloro-3-methylphenol
(para-chloro-meta-cresol)
2-Methylnaphthalene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronaphthalene
2-Nitroaniline
Dimethylphthalate
Acenaphthylene
3-Nitroaniline
Acenaphthene

TABLE 8-2

PHASE II RFI/RI
SOIL, BEDROCK, AND GROUNDWATER SAMPLING
ANALYTES AND COMPOUNDS
OPERABLE UNIT 2
(Continued)

ORGANICS: SEMI-VOLATILES

Target Compound List - Soil and
Bedrock

2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl Phenyl ether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-methylphenol
N-nitrosodiphenylamine
4-Bromophenyl Phenyl ether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Di-n-butylphthalate
Fluoranthene
Pyrene
Butyl Benzylphthalate
3,3'-Dichlorobenzidine
Benzo(a)anthracene
bis(2-ethylhexyl)phthalate
Chrysene
Di-n-octyl Phthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

Target Compound List - Groundwater

2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl Phenyl ether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-methylphenol
N-nitrosodiphenylamine
4-Bromophenyl Phenyl ether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Di-n-butylphthalate
Fluoranthene
Pyrene
Butyl Benzylphthalate
3,3'-Dichlorobenzidine
Benzo(a)anthracene
bis(2-ethylhexyl)phthalate
Chrysene
Di-n-octyl Phthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

TABLE 8-2

**PHASE II RFI/RI
SOIL, BEDROCK, AND GROUNDWATER SAMPLING
ANALYTES AND COMPOUNDS
OPERABLE UNIT 2
(Continued)**

ORGANICS: PESTICIDES/PCBs

**Target Compound List - Soils and
Bedrock**

alpha-BHC
beta-BHC
delta-BHC
gamma-BHC (Lindane)
Heptachlor
Aldrin
Heptachlor Epoxide
Endosulfan I
Dieldrin
4,4'-DDE
Endrin
Endosulfan II
4,4'-DDD
Endosulfan Sulfate
4,4'-DDT
Endrin Ketone
Methoxychlor
alpha-Chlordane
gamma-Chlordane
Toxaphene
AROCLOR-1016
AROCLOR-1221
AROCLOR-1232
AROCLOR-1242
AROCLOR-1248
AROCLOR-1254
AROCLOR-1260

Target Compound List - Groundwater

alpha-BHC
beta-BHC
delta-BHC
gamma-BHC (Lindane)
Heptachlor
Aldrin
Heptachlor Epoxide
Endosulfan I
Dieldrin
4,4'-DDE
Endrin
Endosulfan II
4,4'-DDD
Endosulfan Sulfate
4,4'-DDT
Endrin Ketone
Methoxychlor
alpha-Chlordane
gamma-Chlordane
Toxaphene
AROCLOR-1016
AROCLOR-1221
AROCLOR-1232
AROCLOR-1242
AROCLOR-1248
AROCLOR-1254
AROCLOR-1260

Note: Samples will also be tested for O-phosphate; Ammonia; Silica (as Si or SiO₂); Dissolved Organic Carbon (DOC); Total Organic Carbon (TOC); and Bromide. Analytical procedures have not yet been selected for these analytes.

tetrachloride(CCl_4), methylene chloride, acetone, and chloroform. Operation of the GC, QA requirements, and preparation of the headspace sample will conform to SOP 3.9, Soil Gas Sampling and Field Analysis, and SOPA 10.2, included in this work plan.

8.3.1.3 Physical Analysis

Physical analysis on soil and bedrock samples will consist of classification (ASTM D2488), moisture content (ASTM D2216), and dry density for intact samples (ASTM D2216). Laboratory classification tests will consist of grain size distribution (ASTM D422) (including hydrometer analysis) and Atterberg limits (ASTM D4318). Laboratory classifications will be conducted for a minimum of 10 samples of each general bedrock material type. Laboratory hydraulic conductivity tests will be flexible-wall tests using a triaxial cell with a confining pressure approximating that of the overburden pressure.

8.3.2 Groundwater Samples

Groundwater samples will be collected from all wells identified in Section 8.2. Samples will be measured in the field for pH, specific conductance, and temperature according to SOP 2.5, Measurement of Groundwater Field Parameters. Laboratory analyses for dissolved metals will be performed on samples filtered in the field using a $0.45\text{ }\mu\text{m}$ cellulose acetate filter prior to sample preservation. During the initial investigation, samples will be analyzed for the parameters listed in Table 8-2. Subsequent sampling iterations may only require analyses for contaminants-of-concern. These may be identified after the initial investigation. Samples will be analyzed in accordance with GRRASP.

8.3.3 Sample Containers and Preservation, and Sample Control and Documentation

Sample volume requirements, preservation techniques, holding times, and container material requirements are dictated by the matrix being sampled and by the analyses to be performed. Table 8-3 lists the requirements for samples collected and analyses specified in this FSP.

Additional guidance on the appropriate use of materials and preservatives is provided in SOP 1.13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples.

Sample control and documentation is necessary to ensure the defensibility of data and to verify the quality and quantity of work performed in the field. Accountable documents include logbooks, data collection forms, sample labels or tags, chain-of-custody forms, photographs, and analytical records and reports. Guidance defining the necessary sample control, identification, and chain-of-custody documentation is discussed in SOP 1.13, Containerizing, Preserving, Handling and Shipping of Soil and Water Samples.

TABLE 8-3

SAMPLE TYPES, CONTAINERS, AND PRESERVATION FOR WATER AND SOIL SAMPLES

Sample Type	Analysis	Bottles	Filtered	Preservation	Holding Time	Quantity
Water	Inorganic Chemicals					
	• Anions	Two 1-liter polyethylene bottles	No	Iced to 4°C	28 days	Fill To shoulder
	• Nitrate	One 1-liter polyethylene bottle	No	Iced to 4°C	48 hours	Fill to shoulder
	• Sulfide	One 1-liter polyethylene bottle	No	Iced to 4°C Zinc acetate plus sodium hydroxide to pH > 12	7 days	Fill to shoulder
	- TKN, TOC, Nitrate and Nitrite as N	One 1-liter glass bottle	No	H ₂ SO ₄ to pH < 2; Iced to 4°C	28 days	Fill to shoulder
	- TDS	One 1-liter polyethylene bottle	No	Iced to 4°C	48 hours	Fill to shoulder
	Radiological ^(a)	One 1-gallon polyethylene bottle	Yes	HNO ₃ to pH < 2	6 months	Fill to shoulder
	Tritium	One 1-liter glass bottle	Yes	None	6 months	Fill to shoulder
	TCL ^(b)	One 1-gallon amber glass jar	No	Iced to 4°C	7 days to extraction 40 days to analysis	Fill to shoulder
	- Semi-Volatiles					
	- Volatiles	Two 40-ml Teflon [®] lined glass (VOA) vial	No	Iced to 4°C	7 days*	Fill to top, no air space
	- Dioxins	Two 1-liter amber glass jars	No	Iced to 4°C 0.0008% Na ₂ S ₂ O ₃	7 days	Fill to shoulder
	- Metals	One 1-liter polyethylene bottle	No	HNO ₃ to pH < 2 Iced to 4°C	6 months	Fill to shoulder
	- Cyanides	One 1-liter polyethylene bottle	No	NaOH to pH > 12 C ₆ H ₅ O ₆ in presence of residual Cl ₂ Iced to 4°C	14 days	Fill to shoulder

TABLE 8-3
SAMPLE TYPES, CONTAINERS, AND PRESERVATIVES FOR WATER AND SOIL SAMPLES
(Continued)

Sample Type	Analysis	Bottles	Filtered	Preservation	Holding Time	Quantity
Soil	- Pesticides/PCBs	One 1/2-gallon amber glass jar	No	Iced to 4°C	5 days to extraction 40 days to analysis	Fill to shoulder
	- TAL ^(a) Metals, Semi-Volatile Organics, Pesticides/PCBs; Cyanide	One 1-liter Teflon [®] lined wide-mouth glass jar**	No	Iced to 4°C	10 days	Fill to ¾
	- TCL ^(b) Volatile Organics	One 40-ml Teflon [®] lined wide-mouth glass jar	No	Iced to 4°C	10 days	Fill completely to minimize air space
	- Radiological ^(a)	One 1-liter Teflon [®] lined wide-mouth glass jar**	No	Iced to 4°C	Depends on half-life; not to exceed 45 days	Fill to ¾

^(a) For list of constituents, see Table 8-2.

^(b) For Target Compound List (TCL) and Target Analyte List (TAL) Constituents, see Table 8-2.

* Holding time = 14 days if acidified with HCl to pH < 2.

** As an alternative, soil samples obtained using continuous auger coring equipment may be preserved in 12-inch long sections of polybutyrate sampler liner with Teflon[®] lined plastic end caps sealed with tape.

8.3.4 Field QC Procedures

Sample duplicates, field preservation blanks and equipment rinsate blanks will be prepared. Trip blanks will be obtained from the laboratory. The analytical results obtained for these samples will be used by the ER Project Manager to assess the quality of the field sampling effort. The types of field QC samples to be collected and their application are discussed below. The frequency with which each type is to be collected and analyzed is provided in Table 8-4.

Duplicate samples will be collected by the sampling team and will be used as a relative measure of the precision of the sample collection process. These samples will be collected at the same time, using the same procedures, the same equipment, and in the same types of containers as required for the samples. They will also be preserved in the same manner and submitted for the same analyses as required for the samples.

Field blanks of distilled water, preserved according to the sampling protocol, will be prepared by the sampling team and will be used to provide an indication of any contamination introduced during field sample preparation technique.

Equipment blanks (rinsate) will be collected from a final decontamination rinse to evaluate the success of the field sampling team's decontamination efforts on nondedicated sampling equipment. Equipment blanks are obtained by running distilled water over sampling equipment prior to sample collection. Equipment blanks are applicable to all analyses for water and soil samples as indicated in Table 8-4.

Trip blanks consisting of distilled water will be prepared by the laboratory technician and will accompany each shipment of water samples for volatile organic analysis. Trip blanks will be stored with the group of samples with which they are associated. Analysis of the trip blank will indicate any migration of volatile organics or any problems associated with the shipment, handling, or storage of the samples. As indicated in Table 8-4, all blanks will be prepared at a frequency of 1/20 per shipment.

Procedures for monitoring field QC are given in the site-wide QAPjP.

TABLE 8-4
FIELD QC SAMPLE FREQUENCY

Sample Type	Type of Analysis	Media	
		Solids	Liquids
Duplicates	Organics ^(a)	1/10	1/10
	Inorganics ^(a)	1/10	1/10
	Radiologicals ^(a)	1/10	1/10
Field Preservation Blanks	Organics ^(a)	NA	NA
	Inorganics ^(a)	NA	1/20
	Radiologicals ^(a)	NA	1/20
Equipment Rinsate Blanks	Organics ^(a)	1/20	1/20
	Inorganics ^(a)	1/20	1/20
	Radiologicals ^(a)	1/20	1/20
Trip Blanks	Organics ^(a)	NR	1/20
	Inorganics ^(a)	NR	NR
	Radiologicals ^(a)	NR	NR

NA = Not Applicable

NR = Not Required

^(a) Source: EPA (1986c)

^(b) Source: DOE (1987)

SECTION 9 QUALITY ASSURANCE ADDENDUM (QAA)

This Quality Assurance Addendum QAA supplements the QAPjP dated August 23, 1990, and establishes the specific QA controls applicable to the bedrock field investigation activities described in the Phase RFI/RI Bedrock Workplan, Section 8.0.

9.1 ORGANIZATION AND RESPONSIBILITIES

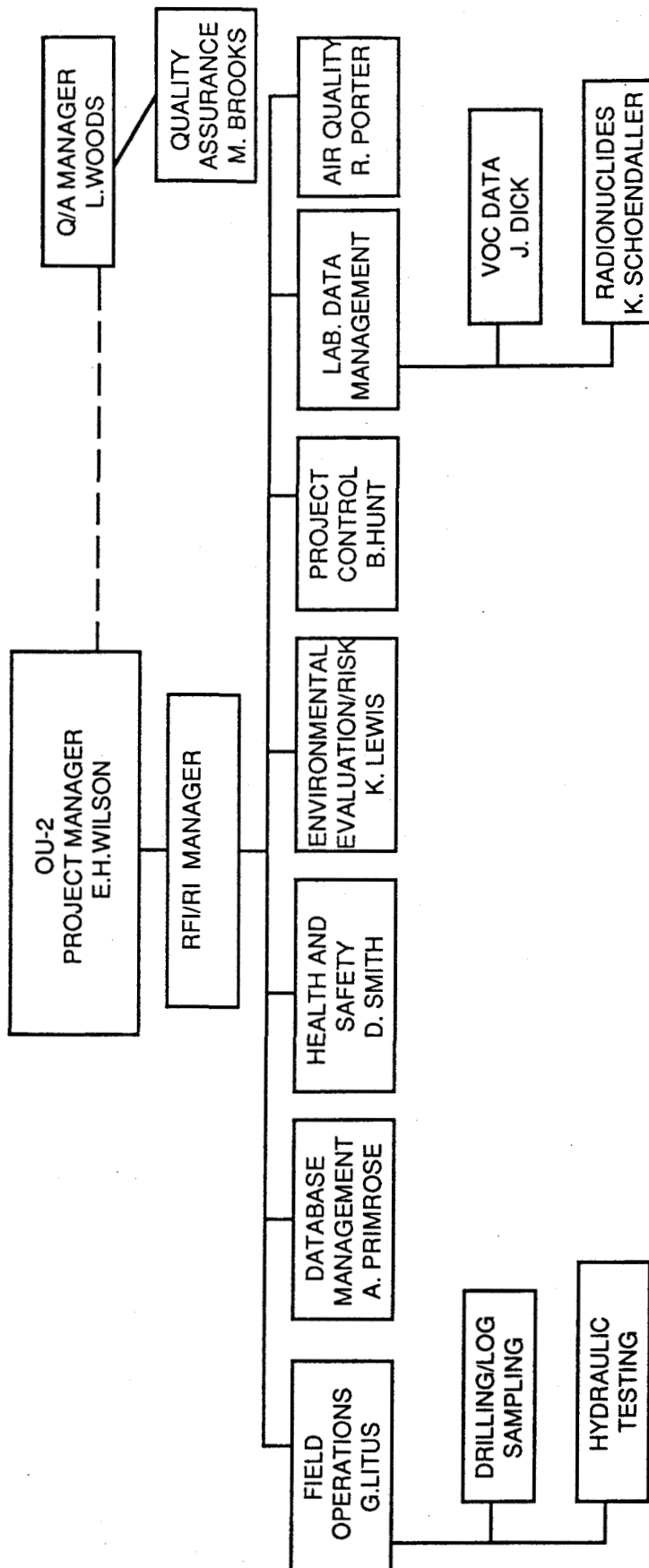
The organization of the EG&G Rocky Flats divisions involved in RFI/RI activities is shown in Figures 1-1 and 1-2 in the QAPjP. Individual responsibilities are described in detail in QAPjP, Subsection 1.3.

Contractors will be tasked by EG&G Rocky Flats to implement the Phase II Bedrock Work Plan/Field Sampling Plan. The specific ER Department personnel who will interface with the Contractors and be authorized to provide technical direction are shown in Figure 9-1.

9.2 QUALITY ASSURANCE PROGRAM

This QAA supplements the QAPjP and establishes the specific QA controls applicable to the field investigation activities described in Bedrock Workplan Section 0. The QAPjP was written to specifically address QA controls for IAG related activities. The content was driven by DOE RFP SOP 5700.6B, which requires that a QA program be implemented for all Rocky Flats Plant activities based on ANSI/ASME NQA-1, "Quality Assurance Requirements for Nuclear Facilities," as well as the IAG which specifies that a QAPjP for IAG-related activities be developed in accordance with EPA QAMS-005/80, "Interim Guidelines and Specifications for Preparing QAPjPs." The 18 element format of NQA-1 was selected as the basis for both the plan and subsequent addenda with the applicable elements of EPA QAMS-005/80 incorporated where appropriate.

All personnel performing activities in accordance with the SOPs specified in this QAA shall receive documented training in the QAA and the applicable SOPs prior to performing the work as specified in QAPjP, Subsection 2.4.



DRAFT

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

**PROJECT MANAGEMENT
ORGANIZATION**

Figure 9-1

1/24/91

9.3 DESIGN CONTROL

9.3.1 Data Quality Objectives (DQOs)

Objectives:

The Phase II field investigation is designed to meet the data quality objectives (DQOs) outlined in Table 9-1.

The DQOs are quantitative and qualitative statements which specify the quality and quantity of data collection required. DQOs are typically expressed in terms of precision, accuracy, representativeness, comparability, and completeness (PARCC). Only precision and accuracy can be expressed in purely quantitative terms. Each of the PARCC parameters is defined in detail in QAPjP Table 9-1. The DQOs for the analytical analysis and field instruments and overall DQOs for field quality control blanks are stated in the site-wide QAPjP. All water and soil analyses will use CLP protocol and are described in QAPjP Table 9-1.

Comparability:

Comparability is a qualitative parameter that shall be ensured by implementation of an approved sampling and analysis plan, standardized analytical protocols, and SOPs for field activities, and by reporting data in uniform units. Comparability is an indicator of how well newly collected data will be compatible with previously collected data and data collected at other locations.

Representativeness:

Representativeness is a qualitative parameter that is ensured through the careful development and review of the sampling and analysis strategy, and the use of appropriate SOPs for sample collection and analysis and field data collection.

Completeness:

Completeness is a quantitative measure of data quality expressed as the percentage of valid or acceptable data obtained from a measurement system. The goal for completeness for data packages is 100 percent, with a minimum acceptable level of 90 percent. All incomplete data packages will be reviewed to determine the cause and corrective action to meet the 100 percent completeness goal.

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Method	Required Detection Limits					Soil/Sed.	Ob.
	SW	GW	SOIL	SED	Water		
EPA 160.2 ^d	X ^u				10 mg/L	NA	25%RPPT
EPA 160.1 ^d	X ^u	X ^F			5 mg/L	NA	25%RPPT
EPA 150.1 ^d	X ^u	X ^F			0.1 pH units	0.1 pH units	NA
EPA CLP SOW ^a	X ^u	X ^F	X	X	200 µg/L ^a	40 mg/Kg ^a	WATER (% RPT)
EPA CLP SOW ^a					60	12	
EPA CLP SOW ^a					10	2	
EPA CLP SOW ^a					200	40	
EPA CLP SOW ^a					5	1.0	
EPA CLP SOW ^a					5	1.0	
EPA CLP SOW ^a					5000	2000	
EPA CLP SOW ^a					10	2.0	
EPA CLP SOW ^a					50	10	
EPA CLP SOW ^a					25	5.0	
EPA CLP SOW ^a					5	10	
EPA CLP SOW ^a					100	20	

TABLE 9-1

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES
(Continued)

Analyte	Method	Required Detection Limits					Precision Objective	Accuracy Objective	
		SW	GW	SOIL	SED	Water			Soil/Sed.
Target Analyte List - Metals (Continued)									
Magnesium	EPA CLP SOW ^a			X	X				
Manganese	EPA CLP SOW ^a					5000 µg/L ^a	2000 mg/Kg ^a	**	***
Mercury	EPA CLP SOW ^a					15	3.0		
Nickel	EPA CLP SOW ^a					0.2	0.2		
Potassium	EPA CLP SOW ^a					40	8.0		
Selenium	EPA CLP SOW ^a					5000	2000		
Silver	EPA CLP SOW ^a					5	1.0		
Sodium	EPA CLP SOW ^a					10	2.0		
Thallium	EPA CLP SOW ^a					5000	2000		
Vanadium	EPA CLP SOW ^a					10	2.0		
Zinc	EPA CLP SOW ^a					50	10		
						20	4.0		
Other Metals									
		X ^u	X ^f	X	X			WATER/SOIL (% RPD)	WATER/SOIL (% Recovery)
Molybdenum	EPA CLP SOW ^b (ICAP)								
Cesium	EPA CLP SOW ^b					8 µg/L ^a	40 mg/Kg ^a	**	***
Strontium	EPA CLP SOW ^b					1000	200		
Lithium	EPA CLP SOW ^b					200	40		
Tin	EPA CLP SOW ^b					100	20		
						200	40		
Other Inorganics									
Percent Solids	EPA 160.3 ^d			X	X	NA	10 mg	**	***
Sulfide	EPA 376.1 ^d			X	X	NA	4 µg/g	**	***

TABLE 9-1

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES
(Continued)

Analyte	Method	Required Detection Limits					Precision Objective	Accuracy Objective
		SW	GW	SOIL	SED	Water			Soil/Sed.
ANIONS								
Carbonate	EPA 310.1 ^d	X ^u	X ^u			10 µg/L	NA	***
Bicarbonate	EPA 310.1 ^d	X ^u	X ^u			10	NA	***
Chloride	EPA 325.2 ^d	X ^u	X ^u			5	NA	***
Sulfate	EPA 375.4 ^d	X ^u	X ^u			5	NA	***
Nitrate as N	EPA 353.2 ^d or 353.3 ^d	X ^u	X ^u			1	NA	***
Fluoride	EPA 340.2 ^d	X ^u	X ^u			5	NA	***
Oil and Grease	EPA 413.2 ^d	X ^u				5	NA	***
*Total Petroleum Hydrocarbons	EPA 418.1 ^d			X	X	NA	10 mg/Kg	NA/80-120
Target Compound List - Volatiles								
Chloromethane	EPA CLP SOW ^e	X ^u	X ^u	X	X	10 µg/L	10 µg/Kg (low) ³	***
Bromomethane	EPA CLP SOW ^e					10	10	
Vinyl Chloride	EPA CLP SOW ^e					10	10	
Chloroethane	EPA CLP SOW ^e					10	10	
Methylene Chloride	EPA CLP SOW ^e					5	5	
Acetone	EPA CLP SOW ^e					10	10	
Carbon Disulfide	EPA CLP SOW ^e					5	5	
1,1-Dichloroethene	EPA CLP SOW ^e					5	5	
1,1-Dichloroethane	EPA CLP SOW ^e					5	5	
total 1,2-Dichloroethene	EPA CLP SOW ^e					5	5	
Chloroform	EPA CLP SOW ^e					5	5	
1,2-Dichloroethane	EPA CLP SOW ^e					0.1	5	
2-Butanone	EPA CLP SOW ^e					1	5	
1,1,1-Trichloroethane	EPA CLP SOW ^e					10	10	
Carbon Tetrachloride	EPA CLP SOW ^e					5	5	
	EPA CLP SOW ^e					5	5	

TABLE 9-1

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES
(Continued)

Analyte	Method	Required Detection Limits					Precision Objective	Accuracy Objective	
		SW	GW	SOIL	SED	Water	Soil/Sed.	WATER/SOIL (% RPD)	WATER/SOIL (% Recovery)
Target Compound List - Volatiles (continued)									
Vinyl Acetate	EPA CLP SOW ^c					10 µg/L	10 µg/Kg (low) ³	**	***
Bromodichloromethane	EPA CLP SOW ^c					5	5		
1,2-Dichloropropane	EPA CLP SOW ^c					5	5		
cis-1,3-Dichloropropene	EPA CLP SOW ^c					5	5		
Trichloroethene	EPA CLP SOW ^c					5	5		
Dibromochloromethane	EPA CLP SOW ^c					5	5		
1,1,2-Trichloroethane	EPA CLP SOW ^c					5	5		
Benzene	EPA CLP SOW ^c					5	5		
trans-1,2-Dichloropropene	EPA CLP SOW ^c					5	5		
Bromoform	EPA CLP SOW ^c					5	5		
4-Methyl-2-pentanone	EPA CLP SOW ^c					10	10		
2-Hexanone	EPA CLP SOW ^c					10	10		
Tetrachloroethene	EPA CLP SOW ^c					5	5		
Toluene	EPA CLP SOW ^c					5	5		
1,1,2,2-Tetrachloroethane	EPA CLP SOW ^c					5	5		
Chlorobenzene	EPA CLP SOW ^c					5	5		
Ethyl Benzene	EPA CLP SOW ^c					5	5		
Styrene	EPA CLP SOW ^c					5	5		
Total Xylenes	EPA CLP SOW ^c					5	5		

TABLE 9-1

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES
(Continued)

Analyte	Method	Required Detection Limits					Precision Objective	Accuracy Objective
		SW	GW	SOIL	SED	Water Soil/Sed.		
Target Compound List - Semi-Volatiles								
Phenol	EPA CLP SOW ^c		X ^u	X	X	10 µg/L	**	***
bis(2-Chloroethyl)ether	EPA CLP SOW ^c					330 µg/Kg ³		
2-Chlorophenol	EPA CLP SOW ^c					10		
1,3-Dichlorobenzene	EPA CLP SOW ^c					10		
1,4-Dichlorobenzene	EPA CLP SOW ^c					10		
Benzyl Alcohol	EPA CLP SOW ^c					10		
1,2-Dichlorobenzene	EPA CLP SOW ^c					10		
2-Methylphenol	EPA CLP SOW ^c					10		
bis(2-Chloroisopropyl)ether	EPA CLP SOW ^c					10		
4-Methylphenol	EPA CLP SOW ^c					10		
N-Nitroso-Dipropylamine	EPA CLP SOW ^c					10		
Hexachloroethane	EPA CLP SOW ^c					10		
Nitrobenzene	EPA CLP SOW ^c					10		
Isophorone	EPA CLP SOW ^c					10		

TABLE 9-1

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES
(Continued)

Analyte	Method	Required Detection Limits					Precision Objective	Accuracy Objective
		SW	GW	SOIL	SED	Water	Soil/Sed.	
Target Compound List - Semi-Volatiles (Continued)								
2-Nitrophenol	EPA CLP SOW ^c		X ^u	X	X	10 µg/L	330 µg/Kg ³	WATER/SOIL (% Recovery)
2,4-Dimethylphenol	EPA CLP SOW ^c					10	330	
Benzoic Acid	EPA CLP SOW ^c					50	1600	
bis(2-Chloroethoxy)methane	EPA CLP SOW ^c					10	330	
2,4-Dichlorophenol	EPA CLP SOW ^c					10	330	
1,2,4-Trichlorobenzene	EPA CLP SOW ^c					10	330	
Naphthalene	EPA CLP SOW ^c					10	330	
4-Chloroaniline	EPA CLP SOW ^c					10	330	
Hexachlorobutadiene	EPA CLP SOW ^c					10	330	
4-Chloro-3-methylphenol	EPA CLP SOW ^c					10	330	
2-Methylnaphthalene	EPA CLP SOW ^c					10	330	
Hexachlorocyclopentadiene	EPA CLP SOW ^c					10	330	
2,4,6-Trichlorophenol	EPA CLP SOW ^c					10	330	
2,4,5-Trichlorophenol	EPA CLP SOW ^c					50	1600	
2-Chloronaphthalene	EPA CLP SOW ^c					10	330	

TABLE 9-1

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES
(Continued)

Analyte	Method	Required Detection Limits					Precision Objective	Accuracy Objective
		SW	GW	SOIL	SED	Water	Soil/Sed.	
Target Compound List - Semi-Volatiles (continued)								
2-Nitroaniline	EPA CLP SOW ^c		X ^u	X	X	50 µg/L	1600 µg/Kg ³	***
Dimethylphthalate	EPA CLP SOW ^c					10	330	
Acenaphthylene	EPA CLP SOW ^c					10	330	
2,6-Dinitrotoluene	EPA CLP SOW ^c					10	330	
3-Nitroaniline	EPA CLP SOW ^c					50	1600	
Acenaphthalene	EPA CLP SOW ^c					10	330	
2,4-Dinitrophenol	EPA CLP SOW ^c					50	1600	
4-Nitrophenol	EPA CLP SOW ^c					50	1600	
Dibenzofuran	EPA CLP SOW ^c					10	330	
2,4-Dinitrotoluene	EPA CLP SOW ^c					10	330	
Diethylphthalate	EPA CLP SOW ^c					10	330	
4-Chlorophenol	EPA CLP SOW ^c					10	330	
Fluorene	EPA CLP SOW ^c					10	330	
4-Nitroaniline	EPA CLP SOW ^c					50	1600	
4,6-Dinitro-2-methylphenol	EPA CLP SOW ^c					50	1600	
N-nitrosodiphenylamine	EPA CLP SOW ^c					10	330	
5-Bromophenyl Phenyl ether	EPA CLP SOW ^c					10	330	
Hexachlorobenzene	EPA CLP SOW ^c					10	330	
Pentachlorophenol	EPA CLP SOW ^c					50	1600	
Phenanthrene	EPA CLP SOW ^c					10	330	
Anthracene	EPA CLP SOW ^c					10	330	
Di-n-butylphthalate	EPA CLP SOW ^c					10	330	
Fluoranthene	EPA CLP SOW ^c					10	330	
Pyrene	EPA CLP SOW ^c					10	330	
Butyl Benzylphthalate	EPA CLP SOW ^c					10	330	
Butyl Benzylphthalate	EPA CLP SOW ^c					10	330	

TABLE 9-1

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES
(Continued)

Analyte	Method	Required Detection Limits					Precision Objective	Accuracy Objective
		SW	GW	SOIL	SED	Water	Soil/Sed.	
Target Compound List - Semi-Volatiles (continued)								
3,3'-Dichlorobenzidine	EPA CLP SOW ^e			X	X	20 µg/L	660 µg/Kg ³	***
Benzo(a)anthracene	EPA CLP SOW ^e					10	330	
Chrysene	EPA CLP SOW ^e					10	330	
bis(2-ethylhexyl)phthalate	EPA CLP SOW ^e					10	330	
Di-n-octyl Phthalate	EPA CLP SOW ^e					10	330	
Benzo(b)fluoranthene	EPA CLP SOW ^e					10	330	
Benzo(k)fluoranthene	EPA CLP SOW ^e					10	330	
Benzo(a)pyrene	EPA CLP SOW ^e					10	330	
Indeno(1,2,3-cd)pyrene	EPA CLP SOW ^e					10	330	
Dibenz(a,h)anthracene	EPA CLP SOW ^e					10	330	
Benzo(g,h,i)perylene	EPA CLP SOW ^e					10	330	

TABLE 9-1

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES
(Continued)

Analyte	Method	Required Detection Limits				Precision Objective	Accuracy Objective
		SW	GW	SOIL	SED	Water	Soil/Sed.
Target Compound List - Pesticides/PCBs							
alpha-BHC	EPA CLP SOW ^c			X	X	0.05 µg/L	8.0 µg/Kg ³
beta-BHC	EPA CLP SOW ^c					0.05	8.0
delta-BHC	EPA CLP SOW ^c					0.05	8.0
gamma-BHC (Lindane)	EPA CLP SOW ^c					0.05	8.0
Heptachlor	EPA CLP SOW ^c					0.05	8.0
Aldrin	EPA CLP SOW ^c					0.05	8.0
Heptachlor Epoxide	EPA CLP SOW ^c					0.05	8.0
Endosulfan I	EPA CLP SOW ^c					0.05	8.0
Dieldrin	EPA CLP SOW ^c					0.10	16.0
4,4'-DDE	EPA CLP SOW ^c					0.10	16.0
Endrin	EPA CLP SOW ^c					0.10	16.0
Endosulfan II	EPA CLP SOW ^c					0.10	16.0
4,4'-DDD	EPA CLP SOW ^c					0.10	16.0
Endosulfan Sulfate	EPA CLP SOW ^c					0.10	16.0
4,4'-DDT	EPA CLP SOW ^c					0.10	16.0
Methoxychlor	EPA CLP SOW ^c					0.5	80.0
Endrin Ketone	EPA CLP SOW ^c					0.10	16.0
alpha-Chlordane	EPA CLP SOW ^c					0.5	80.0

TABLE 9-1

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES
(Continued)

Analyte	Method	Required Detection Limits					Precision Objective	Accuracy Objective
		SW	GW	SOIL	SED	Water	Soil/Sed.	
Target Compound List - Pesticides/PCBs (Continued)								
gamma-Chlordane	EPA CLP SOW ^c		X ^b	X	X	0.5 µg/L	80.0 µg/Kg ³	***
Toxaphene	EPA CLP SOW ^c					1.0	160.0	
AROCLO-1016	EPA CLP SOW ^c					0.5	80.0	
AROCLO-1221	EPA CLP SOW ^c					0.5	80.0	
AROCLO-1232	EPA CLP SOW ^c					0.5	80.0	
AROCLO-1242	EPA CLP SOW ^c					0.5	80.0	
AROCLO-1248	EPA CLP SOW ^c					0.5	80.0	
AROCLO-1254	EPA CLP SOW ^c					1.0	160.0	
AROCLO-1260	EPA CLP SOW ^c					1.0	160.0	
RADIONUCLIDES								
Gross Alpha	f,g,h,i,k,l,m,n	X ^{F,U}	X ^F	X	X	2 pCi/L	4 pCi/g	***
Gross Beta	f,g,h,i,k,l,m,n	X ^{F,U}	X ^F	X	X	4	10	**
Uranium	f,h,i,m,n	X ^{F,U}	X ^F	X	X	0.6	0.3	
233 + 234, 235, 238								
Americium 241	p,q	X ^{F,U}	X ^F	X	X	0.01	0.02	
Plutonium 239 + 240	o,p	X ^{F,U}	X ^F	X	X	0.01	0.03	
Tritium	f,g,h,m	X ^U	X ^U	X	X	400	400 pCi/L	
Strontium TOTAL	f,h,i,m	X ^{F,U}	X ^F	X	X	NA	1 pCi/g	
Strontium 90 only	f,h,i,m	X ^{F,U}	X ^F	X	X	1	NA	
Cesium 137	m	X ^{F,U}	X ^F	X	X	1	0.1	
Radium 226	f,g,h,m ³	X ^{F,U}	X ^F			0.5	0.5	
Radium 228	f,g,h,m ³	X ^{F,U}	X ^F			1	0.5	

TABLE 9-1

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES
(Continued)

Analyte	Method	SW	GW	SOIL	SED	Readability Objective	Accuracy
FIELD PARAMETERS							
pH	1		X	X		± 0.1 pH unit	± 0.2 pH units
Specific Conductance	1		X	X		2.5 µmho/cm ⁷	± 2.5% max. error at 500, 5000, 50000 µmhos/cm plus probe; ± 3.0% max error at 250, 2500, and 25000 plus probe accuracy of ± 2.0%.
						25 µmho/cm ⁸	
						250 µmho/cm ⁹	
Temperature	1		X	X		± 0.1°C	± 1.0°C
Dissolved Oxygen	1		X			± 0.1 mg/L	± 10%

TABLE 9-1

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES (Continued)

* For samples collected from IHSSs 102 and 1065 only [BH101, BH02, BH03, BH04, BH105, BH106, BH07, BH08 (MW33), BH190, BH15, BH16, BH17, BH18, MW01, MW02, MW03, MW33 (BH08)].

** Precision objective = control limit specified in referenced method.

*** Accuracy objective = control limit specified in referenced method.

F = Filtered

U = Unfiltered

1. Measured in the field in accordance with instrument manufacturer's instructions. The instruments to be used are specified in Section 12.

2. Medium soil/sediment required detection limits for pesticide/PCB TCL compounds are 15 times the individual low soil/sediment required detection limit.

3. Detection limits listed for soil/sediment are based on net weight. The detection limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

4. Higher detection limits may only be used in the following circumstance: if the sample concentration exceeds five times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the required detection limit. This is illustrated in the example below:

For lead:

Method in use - ICP

Instrument Detection Limit (IDL) - 40

Sample Concentration - 220

Required Detection Limit (RDL) - 3

The value of 220 may be reported even though the instrument detection limit is greater than the RDL.

Note: The specified detection limits are based on a pure water matrix. The detection limits for samples may be considerably higher depending on the sample matrix.

5. If gross alpha > 5 pCi/L, analyze for radium-226; if radium > 3 pCi/L, analyze for radium-228.

6. The detection limits presented were calculated using the formula in N.R.C. Regulatory Guide 4.14, Appendix Lower Limit of Detection, pg. 21, and follow:

$$LLD = \frac{4.00 (BKG/DUR)^{1/2}}{(2.22)(Eff)(CR)(SR)(e^{-\lambda t})(Aliq)}$$

Where:

LLD = Lower Limit of Detection in pCi per sample unit.

BKG = Instrument Background in counts per minute (CPM).

Eff = Counting efficiency in cpm/disintegration per minute (dpm).

CR = Fractional radiochemical yield.

SR = Fractional radiochemical yield of a known solution.

x = The radioactive decay constant for the particular radionuclide.

t = The elapsed time between sample collection and counting.

TABLE 9-1
(Concluded)

ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Aliq = Sample volume.
DUR = Duration time in minutes.

7. On 500 μ mho/cm range.
8. On 5000 μ mho/cm range.
9. On 50000 μ mho/cm range.
- a. U.S. Environmental Protection Agency Contract Laboratory Program Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, 7/88 (or latest version).
- b. U.S. Environmental Protection Agency Contract Laboratory Program Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, 7/88 (or latest version). The specific method to be utilized is at the laboratory's discretion provided it meets the specified detection limit.
- c. U.S. Environmental Protection Agency Contract Laboratory Program Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration, 2/88 (or latest version).
- d. Methods are from "Methods for Chemical Analysis of Water and Wastes," U.S. Environmental Protection Agency, 1983, unless otherwise indicated.
- e. Methods are from "Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods," (SW-846, 3rd Ed.), U.S. Environmental Protection Agency.
- f. U.S. Environmental Protection Agency, 1979, Radiochemical Analytical Procedures for Analysis of Environmental Samples, Report No. EMSL-LY-0539-1, Las Vegas, Nevada, U.S. Environmental Protection Agency.
- g. American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1985, Standard Methods for the Examination of Water and Wastewater, 16th ed., Washington, D.C., Am. Public Health Association.
- h. U.S. Environmental Protection Agency, 1976, Interim Radiochemical Methodology for Drinking Water, Report No. EPA-600/4-75-008, Cincinnati U.S. Environmental Protection Agency.
- i. Hartley, J.H., ed., 1975, HASL Procedures Manual, HASL-300, Washington, D.C., U.S. Energy Research and Development Administration.
- j. US EPA-600/4-82-057.
- k. "Handbook of Analytical Procedures," USAEC, Grand Junction Lab. 1970, page 196.
- l. "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/4-80-032, August 1980, Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268.
- m. "Methods for Determination of Radioactive Substances in Water and Fluvial Sediments," U.S.G.S. Book 5, Chapter A5, 1977.
- n. "Acid Dissolution Method for the Analysis of Plutonium in Soil," EPA-600/7-79-081, March 1979, U.S. EPA Environmental Monitoring and Support Laboratory, Las Vegas, Nevada, 1979.
- o. "Procedures for the Isolation of Alpha Spectrometrically Pure Plutonium, Uranium, and Americium" by E.H. Essington and B.J. Drennon, Los Alamos National Laboratory, a private communication.
- p. "Isolation of Americium from Urine Samples," Rocky Flats Plant, Health, Safety, and Environmental Laboratories.
- q. "Radioactivity in Drinking Water," EPA 570/9-81-002.

9.3.2 Sampling Locations

Sampling locations for groundwater sediments, subsurface soil, surface, soil, and surface water are specified in the Bedrock Work Plan, Section 8.0.

9.3.3 Hydrologic Testing

The hydrologic testing program to be used at the 903 Pad, Mound, and East Trenches Areas is specified in the Bedrock Work Plan, Subsection 5.1.1.4. Hydrologic testing will be performed in accordance with the EG&G SOPs, specified in Table 9-2.

9.3.4 Equipment Decontamination

Non-dedicated sampling equipment shall be decontaminated between sampling locations in accordance with the EG&G SOPs specified in Table 9-2. Other equipment (e.g., heavy equipment) potentially contaminated during drilling, hydrogeologic/geologic testing, boring, sample collection, etc., shall also be decontaminated as specified in the applicable EG&G SOPs.

9.3.5 Quality Control Checks

To assess the quality of the field sampling technique, collection of field quality control (QC) samples are incorporated into the sampling scheme. Field QC sample collection frequencies for the Phase II 903 Pad, Mound, and East Trenches Areas field investigations are shown in Table 9-3. In addition, a QC sample, which shall consist of an extra volume of a designated field sample, shall be collected at a 5-percent frequency for each specific sample matrix. Adequate volume of the QC sample shall be collected and submitted to the laboratory to allow for the analysis of spikes, duplicates, and serial dilutions to provide the laboratory a check on its internal operations, as required by CLP protocol. The volume required for the QC sample shall be double that of a normal sample.

Objectives for Field Quality Control Samples:

Field quality control objectives are shown in Table 9-1.

9.3.6 Analytical Procedures

Analytical procedures and DQOs are shown in Table 9-1.

Table 9-2
APPLICABLE SOPs

Standard Operating Procedures		Well Drilling, Development										Surface Water				Sediment				Surface Soil				Subsurface Soil/Water				Hydrologic Testing				Source				Biota																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
		Completion	Groundwater	Surface Water	Sediment	Surface Soil	Subsurface Soil/Water	Hydrologic Testing	Source	Biota	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sampling	Sa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X - As required by H&S plan.

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Table 9-2
(continued)

APPLICABLE SOPS

Standard Operating Procedures

	Well Drilling, Development	Ground-Water Sampling	Surface-Water Sampling	Sediment Sampling	Surface Soil Sampling	Subsurface Soil Sampling	Hydrologic Testing	Source Sampling	Bioa Samples
3.2 Drilling and Sampling Using Hollow-Stem Auger Techniques									
a) Drilling	•								
b) Continuous Auger Coring	•								
c) Drive Samples	•								
3.3 Isolating Bedrock from the Alluvium with Grouted Surface Casing									
a) In Borings	•								
b) In Monitor Wells	•								
3.4 Rotary Drilling and Rock Coring									
a) Air	•								
b) Water	•								
3.5 Plugging and Abandonment of Boreholes	•								
3.6 Monitoring Well and Piezometer Installation	•								
3.8 Surface Soil Sampling	•								
3.9 Soil Gas Sampling and Field Analysis									
3.10 Borehole Clearing									
4.1 Surface Water Data Collection Activities		•							
4.2 Field Measurement of Surface Water Parameters		•							
4.3 Surface Water Sampling		•							
4.4 Discharge Measurements		•							
4.5 Base Laboratory Work	•	•	•	•	•	•	•	•	•
4.6 Sediment Sampling				•					
TBD Collection of Waste Samples								•	
TBD Controlling the Interaction of Surface Water with Groundwater	•							•	
TBD Sampling Footing Drains, Cleanouts, and Manholes								•	
TBD Installation of Wellpoints								•	

APPLICABLE SOPs

TBD Collection of Waste Samples

856X0045

Note: Field sampling SOP's for biota are in development and will be provided along with the environmental evaluation work plan to EPA and CDH for review prior to conducting work.

TABLE 9-3
FIELD QC SAMPLE COLLECTION FREQUENCY

<u>Activity</u>	<u>Frequency</u>
Field Duplicate	1 in 20 ¹
Trip Blank ²	1 per shipping container ³
Equipment Rinsate Blank	1 in 20 ⁴
Triplicate Samples (benthic samples)	For each sampling site.
Drilling and Decontamination Fluids	Sample source and analyze for all analytes of interest prior to use.

1. Or per sampling event, whichever is more frequent.
2. For samples to be analyzed for volatile organics only.
3. A trip blank shall not be used for radiochemistry samples because radionuclide samples are less likely to be contaminated from direct exposure to air than are samples of volatile organics.
4. One equipment rinsate blank in twenty samples for each specific sample matrix being collected when non-dedicated equipment is being used.

9.3.7 Data Reduction, Validation, and Reporting

Analytical Reporting Turnaround Times:

Contractually required analytical reporting turnaround times are shown in QAPjP Table 3-1.

Data Validation:

Data validation entails an examination of the sample data package which includes the QC data and the raw sample data to verify that the field and laboratory data falls within the required control limits, the analytical results are correctly transcribed from the instrument printouts, and which, if any, field samples are related to any laboratory QC samples found to be beyond control limits. The objective of data validation is to identify any unreliable or invalid field or laboratory measurements and also to verify compliance with the analytical protocols and field SOPs. The methods that shall be used to perform laboratory data validation are shown in Table 9-4. Field data validation shall be performed as specified in QAPjP Subsection 3.3.3.2.

Data Reduction:

Reduction of laboratory measurements and laboratory reporting of analytical parameters shall be in accordance with the procedures specified for each analytical method (Table 9-1). The reduced data will be used in the data validation process to verify that the laboratory control and the overall system DQOs have been met.

9.4 PROCUREMENT DOCUMENT CONTROL

Contractors shall be utilized to perform the RFI/RI field investigation described in the FSP. The Contractors shall be required to implement all requirements contained in the Work Plan/Field Sampling Plan, the QAPjP, this QAA, and all SOPs referenced in these documents. Analytical services will also be contracted for analysis of field samples. Appropriate requirements from the QAPjP, this QAA, and the GRRASP shall be passed on to any organizations performing these analyses. A Contractor may also be utilized to validate analytical data packages. Appropriate requirements from this QAA shall be transmitted to the validation Contractor.

The implementing Contractors shall be required to provide the materials necessary for performing the work described in the FSP.

The Contractor shall be required to submit a QA Program that meets the applicable requirements in the QAPjP, this QAA, NQA-1, and EPA QAMS-005/80.

TABLE 9-4

DATA VALIDATION GUIDELINES

Data validation shall be performed by EMAD or Contractor personnel in accordance with the following functional guidelines:

- U.S. EPA, Laboratory Data Validation Functional Guidelines for Evaluating Organics Data (2/88).
 - U.S. EPA, Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Data (7/88).
 - EG&G Rocky Flats, Water Quality Parameter Data Validation Guidelines (3/90).
 - EG&G Rocky Flats, Radiochemical Data Validation Guidelines - Radium 226 Analysis of Soil and Water by Radon Emanation (Version 2.0, Rev. May 1990).
 - EG&G Rocky Flats, Radiochemical Data Validation Guidelines - Isotopic Analyses by Alpha Spectrometry (Version 2.0, Rev. May 1990).
 - EG&G Rocky Flats, Radiochemical Data Validation Guidelines - Tritium Analyses by Liquid Scintillation (Version 2.0, Rev. May 1990).
 - EG&G Rocky Flats, Radiochemical Data Validation Guidelines - Gross Alpha/Beta by Gas Proportional Counters (Version 2.0, Rev. May 1990).
 - EG&G Rocky Flats, Radiochemical Data Validation Guidelines - Gamma Spectroscopy (in preparation).
-

9.5 INSTRUCTIONS, PROCEDURES, AND DRAWINGS

The FSP in the Bedrock Work Plan, Section 8.0 describes the activities to be performed. The plan shall be reviewed and approved in accordance with the requirements for instructions, procedures, and drawings specified in QAPjP Section 5.

SOPs approved for use for RFI/RI are identified in Table 9-2, which also indicates their applicability. Any additional quality-affecting procedures proposed for use but not identified here shall be developed and approved as required in QAPjP Section 5.0 prior to performing the affected activity.

9.6 DOCUMENT CONTROL

The following documents, as a minimum, shall be controlled in accordance with the requirements specified in Section 6.0 of the QAPjP/EE QAPjP:

- Phase II 903 Pad, Mound, East Trenches Areas RFI/RI Work Plan (Bedrock);
- Rocky Flats Plant Site-Wide Quality Assurance Project Plan for CERCLA RI/FS and RCRA RFI/CMS Activities (QAPjP);
- Quality Assurance Addendum to the Rocky Flats Site-Wide QAPjP for CERCLA RFI/RI and RCRA RFI/CMS Activities for Operable Unit 2, 903 Pad, Mound, East Trenches Areas Phase II RFI/RI Activities; and
- SOPs (all SOPs specified in the QAPjP and this QAA).

9.7 CONTROL OF PURCHASED ITEMS AND SERVICES

The Contractors that shall provide services identified in Section 4 of this QAA shall be selected and evaluated as specified in Section 9.0 of the QAPjP. This includes pre-award evaluation/audit of proposed Contractors as well as periodic audit of the acceptability of Contractor performance during the life of the contract (as applicable). Such audits shall be performed at least annually or once during the life of the project, whichever is more frequent (see also Section 18.0 of the QAPjP).

9.8 IDENTIFICATION AND CONTROL OF ITEMS, SAMPLES, AND DATA

9.8.1 Sample Containers/Preservation

Appropriate sample volumes, containers, and preservation requirements for RFI/RI shall be in accordance with the SOPs listed in Table 7-2 and Table 9-5. Requirements for environmental evaluation are included in the Environmental Work Plan (Section 6) and SOPs which are to be developed.

9.8.2 Sample Identification

RFI/RI samples shall be labeled and identified in accordance with the SOPs specified in Table 7-2 and shall have unique identification that traces the sample to the source(s) and indicates the method(s), date, the sampler(s), and conditions prevailing at the time of sampling. Sample identification requirements for environmental evaluation samples are included in Section 6.0.

9.8.3 Chain-of-Custody

A required part of any sampling and analytical program is the integrity of the sample from collection to data reporting. The documentation of the sample's history is referred to as chain-of-custody. Sample chain-of-custody shall be maintained as specified in Section 8.3.2.4 of the QAPjP through the application of the SOPs specified in Table 9-2 for environmental samples collected during field investigations.

9.9 CONTROL OF PROCESSES

Those activities requiring control are governed by EG&G SOPs (Table 9-2) and other portions of this QAA (and the QAPjP).

9.10 INSPECTION

Procured materials and construction activities (e.g., ground-water monitoring well installation) shall be inspected (as applicable) in accordance with the requirements specified in Section 10.0 of the QAPjP.

9.11 TEST CONTROL

Test control requirements shall apply to Treatability Studies when they are performed. Such tests shall be performed and documented in accordance with the requirements for test control specified in Section 11.0 of the QAPjP.

9.12 CONTROL OF MEASURING AND TEST EQUIPMENT (M&TE)

9.12.1 Field Equipment

Specific conductivity, temperature, pH, and dissolved oxygen content of water samples shall be measured in the field. Field measurements shall be taken and the instruments calibrated as specified in EG&G procedure SW-SOP-4.2 (Table 9-2).

Each piece of field equipment shall have a protocol package, as specified by the SOPs shown in Table 9-2, that contains:

- Standard operating procedures (i.e., EG&G SW-SOP 4.2);
- Routine preventative maintenance procedures, including a list of critical spare parts to be provided or available in the field;
- Calibration methods, frequency, and description of the calibration solutions; and
- Standardization procedures (traceability to nationally recognized standards).

The above information shall, in general, conform to the manufacturer's recommended operating procedures or shall explain the deviation from said procedures.

Any other measurements or M&TE not discussed here shall be calibrated and maintained in accordance with manufacturer's instructions (if calibration and maintenance are addressed) or the SOP listed in Table 9-2.

9.12.2 Laboratory Equipment

Laboratory analyses will be performed by contracted laboratories using methods shown in Table 9-1.

9.13 HANDLING, STORAGE, AND SHIPPING

RFI/RI samples shall be packaged, transported, and stored in accordance with the applicable SOPs specified in Table 9-2 and requirements shown in Table 9-5.

The implementing Contractor shall develop and implement an SOP for handling and storing construction materials to ensure only appropriate, accepted materials are used and are handled and stored to prevent contamination or damage prior to use/installation.

TABLE 9-5
SAMPLE CONTAINERS, SAMPLE PRESERVATION,
AND HOLDING TIMES FOR WATER, SOIL, AND SEDIMENTS

SOIL AND SEDIMENT

<u>Analyte</u>	<u>Container</u>	<u>Preservative</u>	<u>Holding Time</u>
TAL Metals	8 oz. glass	4°C	180 days (Hg 28 days)
Non-TAL Metals	8 oz. glass	4°C	180 days
pH	8 oz. glass	4°C	ASAP
Nitrate	8 oz. glass	4°C	48 hours
Sulfide	8 oz. glass	4°C	28 days
Percent Solids	8 oz. glass	4°C	
TCL Volatiles	4 oz. glass, Teflon-lined cap	4°C	14 days
TCL Base/Neutral/Acids	8 oz. glass, Teflon-lined cap	4°C	7 days/40 days ²
TCL Pesticides/PCBs	8 oz. glass, Teflon-lined cap	4°C	7 days/40 days ²
Petroleum Hydrocarbons	8 oz. glass, Teflon-lined cap	4°C	7 days/40 days ²
Gross Alpha/Beta	32 oz. glass	None	180 days
Plutonium 239 + 240	32 oz. glass	None	180 days
Americium 241	32 oz. glass	None	180 days
Uranium 233 + 234, 235, 238	32 oz. glass	None	180 days
Strontium 89, 90	32 oz. glass	None	180 days
Cesium 137	32 oz. glass	None	180 days
Tritium	32 oz. glass	None	180 days

WATER

<u>Analyte</u>	<u>Container</u>	<u>Preservative</u>	<u>Holding Time</u>
TAL Metals	1 L Poly.	HNO ₃ to pH < 2, 4°C	180 days (Hg 28 days)
Non-TAL Metals	1 L Poly.	HNO ₃ to pH < 2, 4°C	180 days (Hg 28 days)
Carbonate	500 mL Poly.	4°C	14 days
Bicarbonate	500 mL Poly.	4°C	14 days
Chloride	500 mL Poly.	4°C	28 days
Sulfate	500 mL Poly.	4°C	28 days
Nitrate	500 mL Poly.	4°C	48 hours

TABLE 9-5 (cont'd)
SAMPLE CONTAINERS, SAMPLE PRESERVATION,
AND HOLDING TIMES FOR WATER, SOIL, AND SEDIMENTS

WATER (cont'd)

<u>Analyte</u>	<u>Container</u>	<u>Preservative</u>	<u>Holding Time</u>
Fluoride	500 mL Poly.	4°C	28 days
Total Suspended Solids (SW)	500 mL Poly.	4°C	7 days
pH	500 mL Poly.	4°C	ASAP
Total Dissolved Solids	100 mL Poly.	4°C	7 days
Cyanide	500 mL Poly.	NaOH to pH > 12, 4°C	12 days
TCL Volatiles	3-40 mL vials w/Teflon- lined septum caps	4 drops conc. HCl, 4°C	14 days
TCL Base/Neutral/Acids ¹	1 L Amber glass	4°C	7 days/ 40 days ²
TCL Pesticides/PCBs	1 L Amber glass	4°C	7 days/ 40 days ²
Gross Alpha/Beta	2-1L Poly.	HNO ₃ pH < 2	180 days
Radium 226, 228	2-1L Poly.	HNO ₃ pH < 2	180 days
Tritium	100 mL Glass	None	None
Uranium 233+234, 235, 238	1 L Poly.	HNO ₃ pH < 2	180 days
Strontium Total	1 L Poly.	HNO ₃ pH < 2	180 days
Cesium 137	1 L Poly.	HNO ₃ pH < 2	180 days
Americium 241	2.5 L Poly.	HNO ₃ pH < 2	180 days
Plutonium 239+240	2.5 L Poly.	HNO ₃ pH < 2	180 days

1. TCL semi-volatiles.
2. 7 days from collection to extraction, 40 days from extraction to analysis.

9.14 STATUS OF INSPECTION, TEST, AND OPERATIONS

The requirements for the identification of inspection, test, and operating status shall be implemented as specified in Section 14.0 of the QAPjP. A log specifying the status of all boreholes and groundwater monitoring wells shall be maintained.

9.15 CONTROL OF NONCONFORMANCES

The requirements for the identification, control, evaluation, and disposition of nonconforming items, samples, and data identified by EG&G shall be implemented as specified in Section 15.0 of the QAPjP. Nonconformances identified by the implementing contractor shall be submitted to EG&G for concurrence and approval of the proposed corrective action(s) and disposition.

9.16 CORRECTIVE ACTION

The requirements for the identification, documentation, and verification of corrective actions for conditions adverse to quality identified by EG&G shall be implemented as specified in QAPjP Section 16. Conditions adverse to quality identified by the implementing contractor shall be documented and submitted to EG&G for approval of the proposed corrective action(s).

9.17 QUALITY ASSURANCE RECORDS

All QA records shall be maintained in accordance with the methods established in QAPjP Section 17. QA records to be generated during the Phase II field activities include, but are not limited to:

- Field Logs (e.g., sample collection notebooks/logs for water, sediment, and air)
- Calibration Records
- Sample Collection & Chain-of-Custody Records
- Drilling Logs
- Hydrologic Testing Documentation
- Geologic Testing Documentation
- Work Plan/Field Sampling Plan
- QAPjP/QAA
- Audit/Surveillance/Inspection Reports
- Nonconformance Reports
- Corrective Action Documentation
- Data Validation Results
- Analytical Results
- Procurement/Contracting Documentation

- Training/Qualification Records
- Inspection Records

9.18 QUALITY VERIFICATION

The requirements for the verification of quality shall be implemented as specified in (QAPjP) Section 18.0. Audits of Contractors providing field investigation, construction, and analytical support services shall be performed at least annually or once during the life of the project, whichever is more frequent (see also QAPjP Section 18.0).

9.19 SOFTWARE CONTROL

The requirements for the control of software shall be implemented as specified in QAPjP Section 19.0. Only database software is anticipated to be used at this time. EG&G SOPs applicable to the use of the database for storing environmental data are specified in QAPjP Table 9-2.

10.1 SOP ADDENDUM TO SOP NO. 2.6: DETECTION AND SAMPLING OF NON-AQUEOUS PHASE LIQUIDS IN MONITORING WELLS

10.1.1 Introduction

Wells screened across the bedrock/alluvial interface or at other zones of vertical permeability contrast have the greatest potential for containing dense non-aqueous phase liquids. These wells and any other wells where DENSE or light non-aqueous phase liquids are suspected will be checked for these contaminants during groundwater sampling. Samples of the non-aqueous phase liquids will be collected if present.

10.1.2 Determination of the Depth and Thickness of Non-Aqueous Phase Immiscible Layers

The presence of immiscible layers will be checked for using an interface probe. Prior to use, the interface probe will be decontaminated following SOP No. 1.3, General Equipment Decontamination. The interface probe will have differing sound tones or patterns to distinguish between aqueous and immiscible organic layers. As with water level measurements, the probe will be sufficiently accurate to measure water levels to the nearest 0.01 foot. Manufacturer's instructions and SOP No. 2.1, Water Level Measurements In Wells and Piezometers, will be followed to measure the depth to the bottom of the well, the depth to the non-aqueous/aqueous layer interface, and the depth to the top of the water column or non-aqueous layer/air interface. All depths will be recorded to the nearest 0.01 foot. The probe will be moved slowly up and down to determine the point where the indicator tone or sound is reproducibly obtained. Measurements will be considered reproducible when consecutive readings do not differ by more than ± 0.02 foot. The average of the reproducible readings will be used to determine the measurement level. Care will be taken when lowering and raising the probe to minimize rubbing of the tape against the well casing. Once measurement levels have been determined, the probe will be retrieved and decontaminated according to SOP No. 1.3, General Equipment Decontamination.

10.1.3 Collection of Non-Aqueous Phase Liquid Samples

If detected, non-aqueous phase liquid samples will be collected before purging activities begin. The method of choice for collecting immiscible layer samples is dependent on the thickness of the layer and the depth to the surface of the layer. When the thickness of the floating layer is less than 2 feet, a peristaltic pump or a bailer which fills from the top will be used. If the thickness of the phase is 2 feet or greater, samples will be collected with a bottom-valve bailer. Dense immiscible liquids will be collected with a bottom

double-check-valve bailer before purging the well. In all cases, care will be taken to carefully lower the bailer into the well so that minimal agitation of the immiscible layer is achieved.

Equipment used for collecting non-aqueous phase liquid samples will be cleaned before use. All sample containers will consist of bottles precleaned to EPA specifications. The following procedure will be followed when sampling wells with immiscible layers.

- The bailer and bailer line will be precleaned following the procedures outlined in SOP No. 1.3, General Equipment Decontamination.
- Bailers and line will be wrapped in aluminum foil for transport to the field or from one site to the next.
- The bailer intake will be carefully lowered to the midpoint of the immiscible layer and the bailer filled while it is being held at this level. The bailer will be lowered into the immiscible layer slowly so that minimal agitation of the immiscible layer occurs. If a layer floating immiscible liquid less than 2 feet thick is being collected, use a top-filling bailer or peristaltic pump. If a floating layer greater than 2 feet thick is being collected, the bottom filling bailer or peristaltic pump is preferable. If a dense liquid layer is being collected, use the double check valve bailer.
- At no time will the bailer or line be allowed to touch the ground or otherwise come in contact with other objects that might introduce contaminants into the well.
- Sampling will follow the procedures specified for the collection of volatile organics in SOP No. 2.6, Groundwater Sampling.

10.2 SOP ADDENDUM TO SOP NO. 3.9: FIELD HEADSPACE ANALYSIS BY PORTABLE GC METHODS

10.2.1 Introduction

Samples of unweathered and weathered bedrock will be collected from boreholes for field headspace analysis by GC methods. The analyses will check for carbon tetrachloride (CCl_4), trichloroethylene (TCE), tetrachloroethylene (PCE), methylene chloride, acetone, and chloroform.

10.2.2 Obtaining and Preparing Samples

Immediately after the sampler is opened, a sufficient quantity of soil or bedrock will be obtained from a segment of core to approximately half-way fill a 250 ml. wide-mouth glass container fitted with a septum top. The sample will be broken up in the jar as much as possible for approximately a 30-second interval and then immediately capped. After capping, the sample will be inverted and then transported to the base lab within 4 hours of sampling. Once at the base lab, the sample will be weighed and the weight of the soil or bedrock determined by subtracting the predetermined weight of the empty container from the container with sample. The sample containers will be placed in a constant temperature chamber or water bath maintained at 25° C for 1 hour. After 1 hour, the sample container will be turned upright and allowed to sit five minutes, and a syringe will be used to extract an appropriate aliquot (typically 100 μ l) based on expected levels of contamination. The gas chromatograph manufacturer's operating manual will be followed for sample injection and operation.

Each day, prior to sample analysis, inject and analyze a blank and two standards. One standard mixture will be prepared at concentrations 2 to 3 times the minimum detection limit while concentrations in the other standard will be prepared at 1 to 2 times the upper range expected in the sample. Prior to running the first field sample the system will be purged and acceptable blank values obtained.

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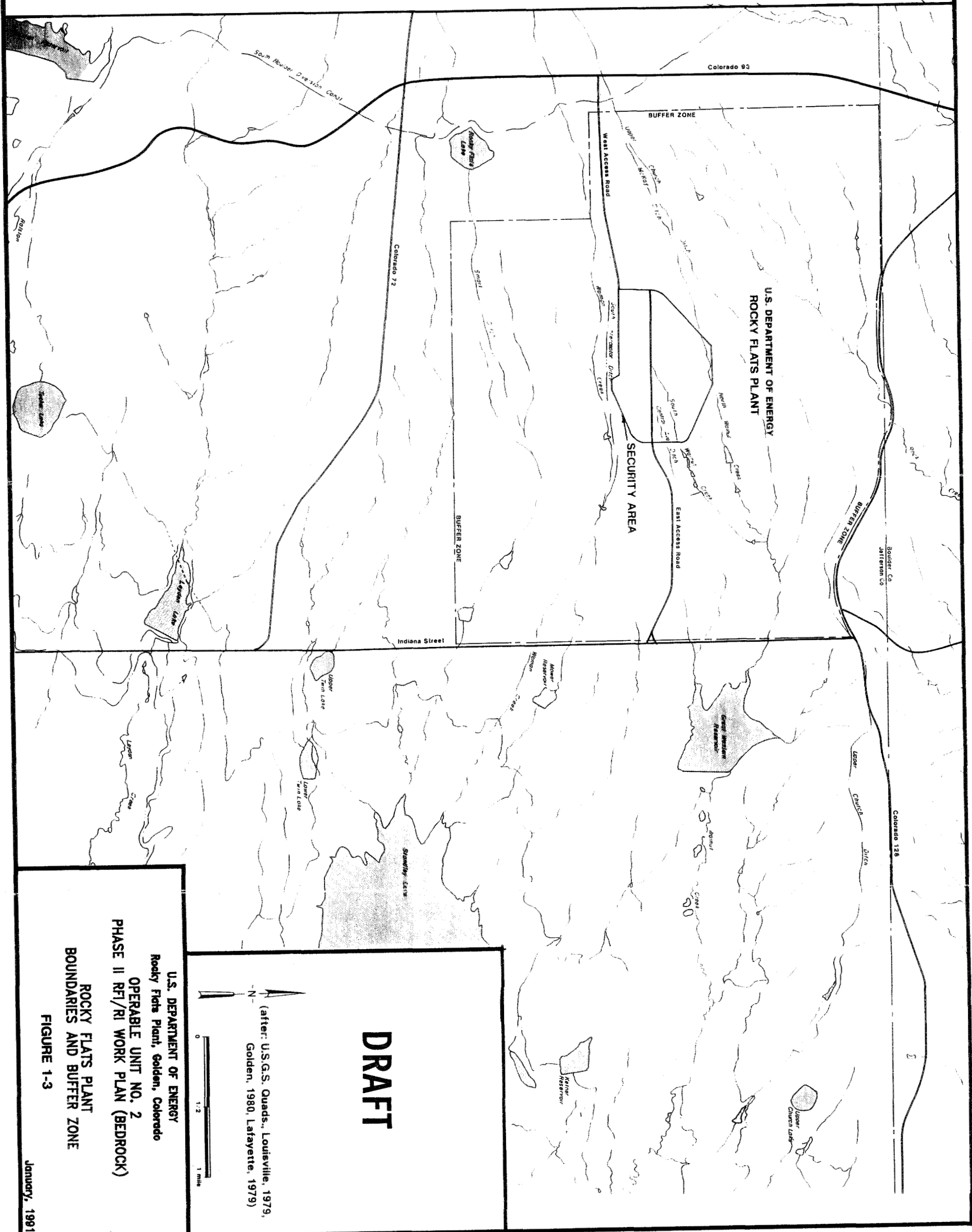
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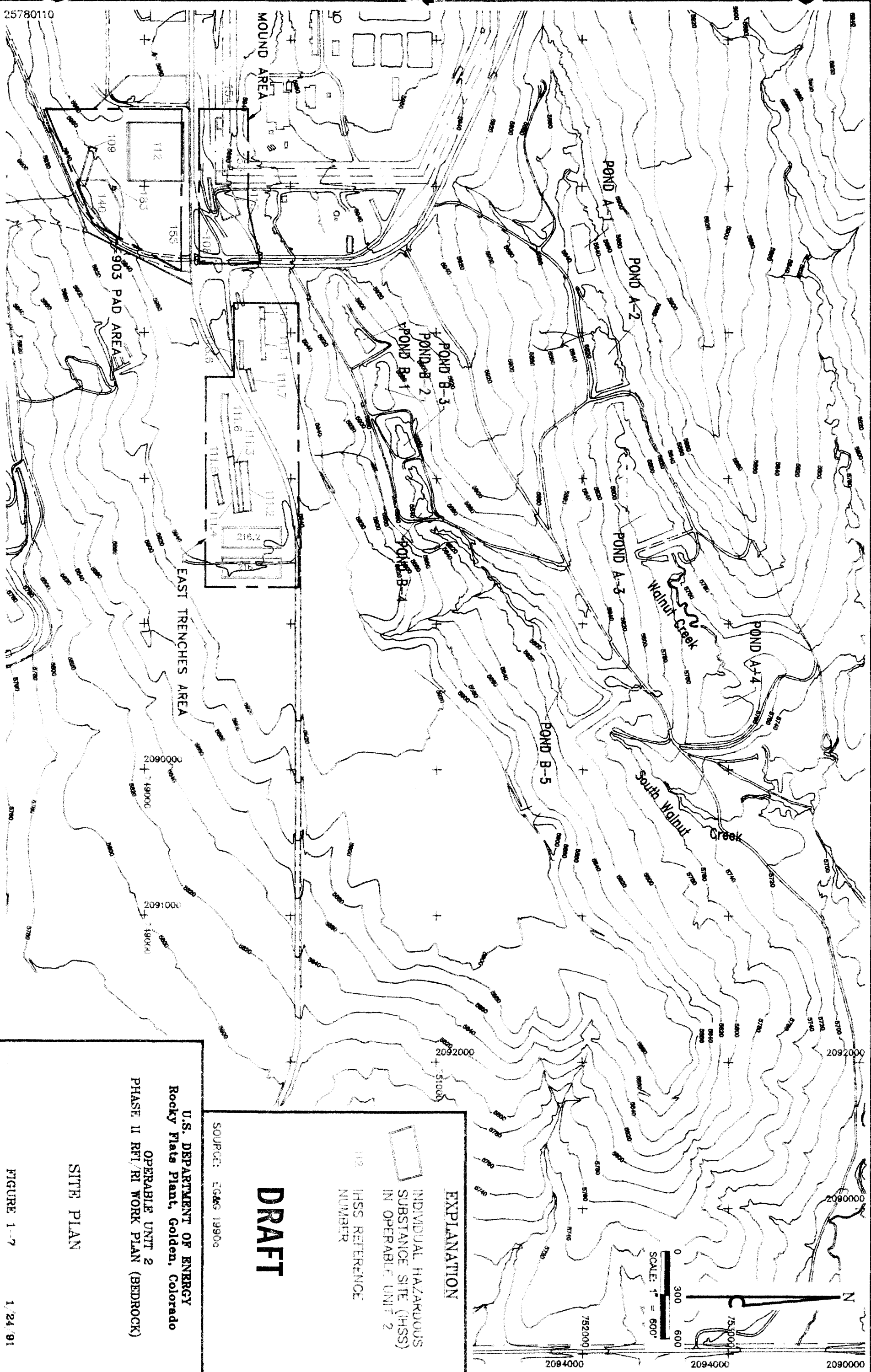
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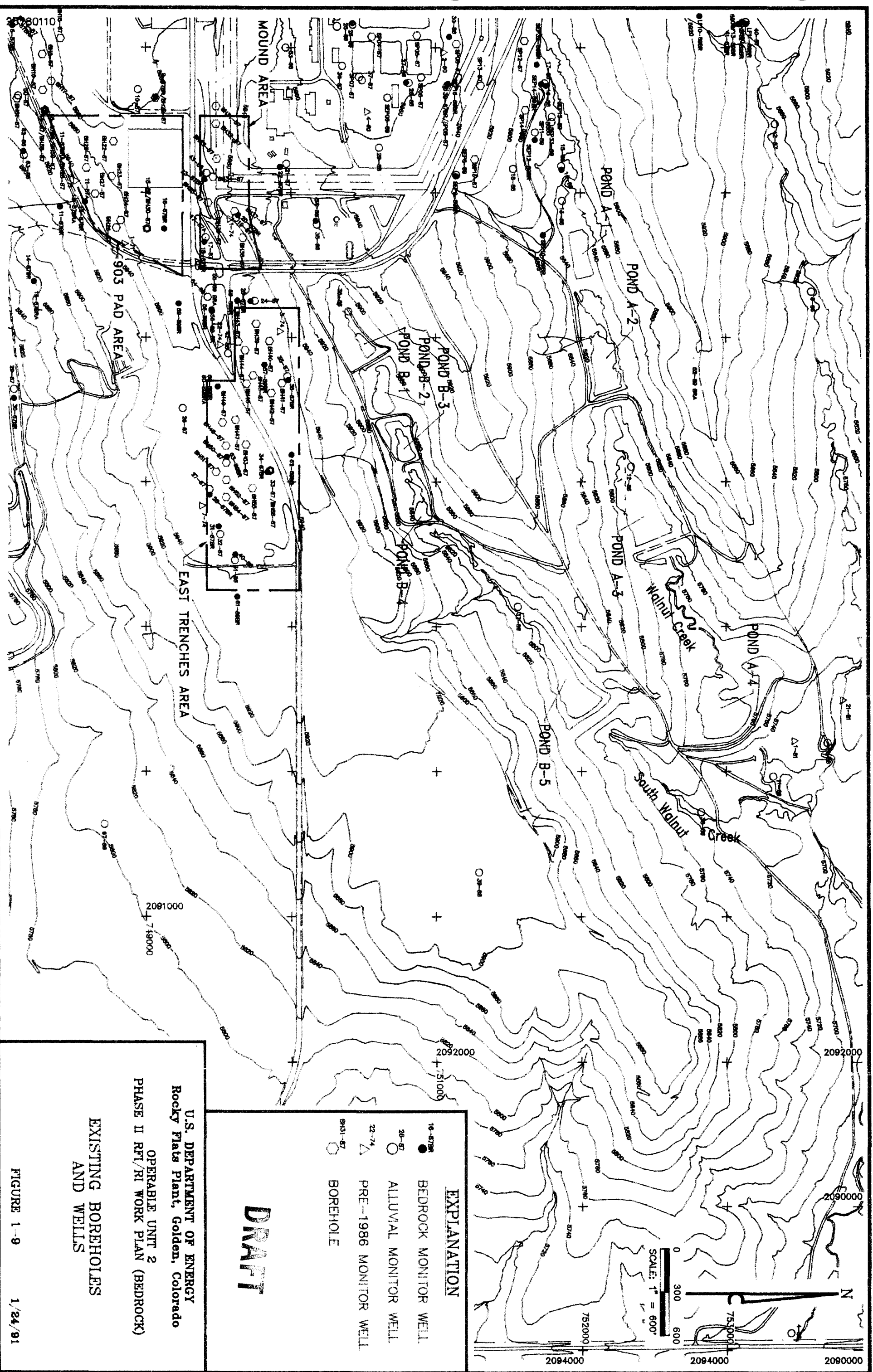
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EXPLANATION

- 16-8736 BEDROCK MONITOR WELL.
- 26-57 ALLUVIAL MONITOR WELL.
- △ 22-714 PRE-1986 MONITOR WELL.
- 8431-87 BOREHOLE

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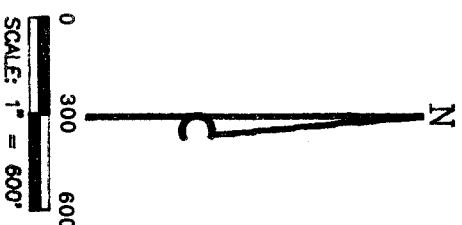
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFT/RI WORK PLAN (BEDROCK)
EXISTING BOREHOLES
AND WELLS

FIGURE 1-9 1/24/91



SOURCE: EG&G 1990c

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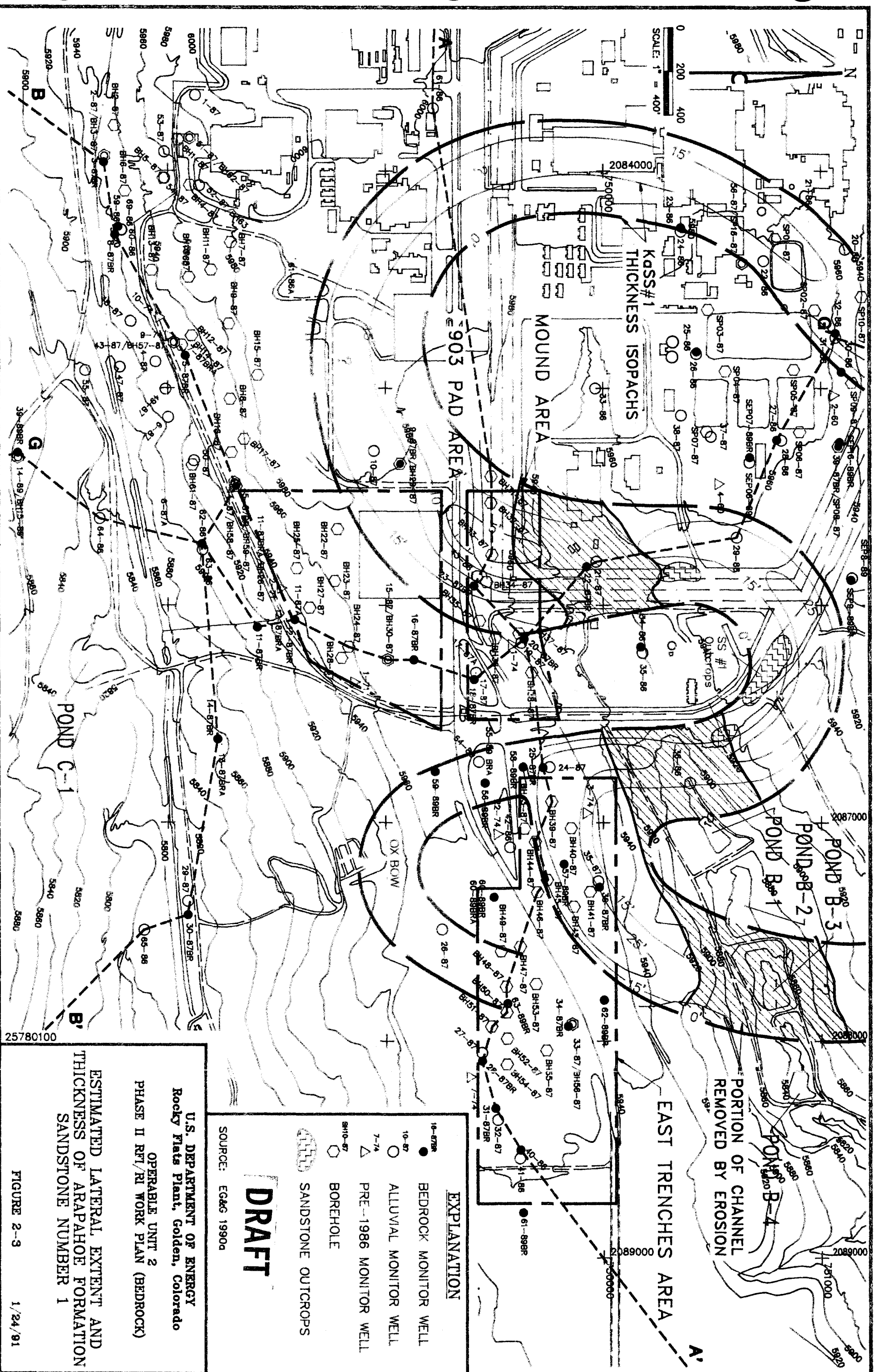


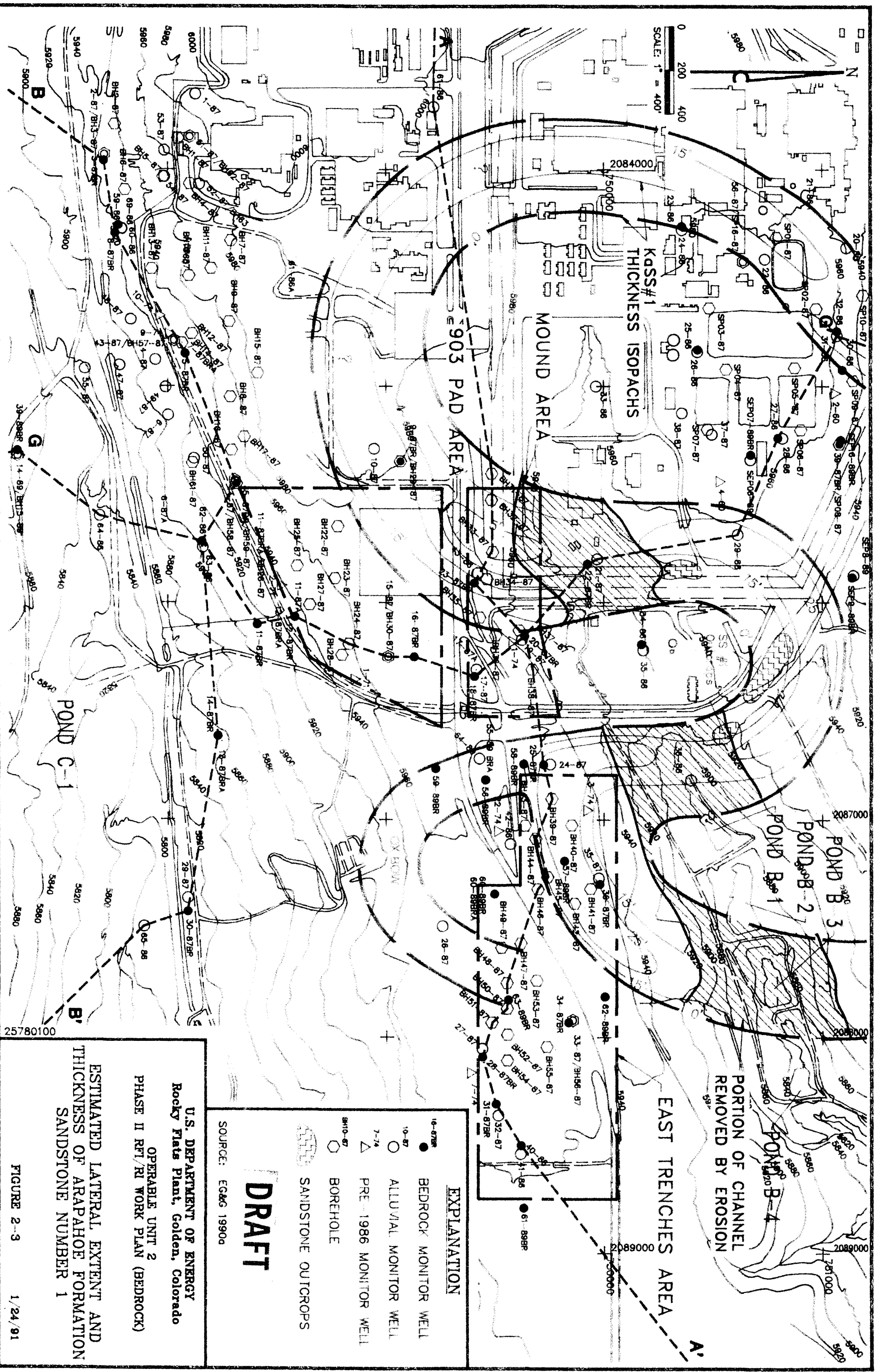
EXPLANATION

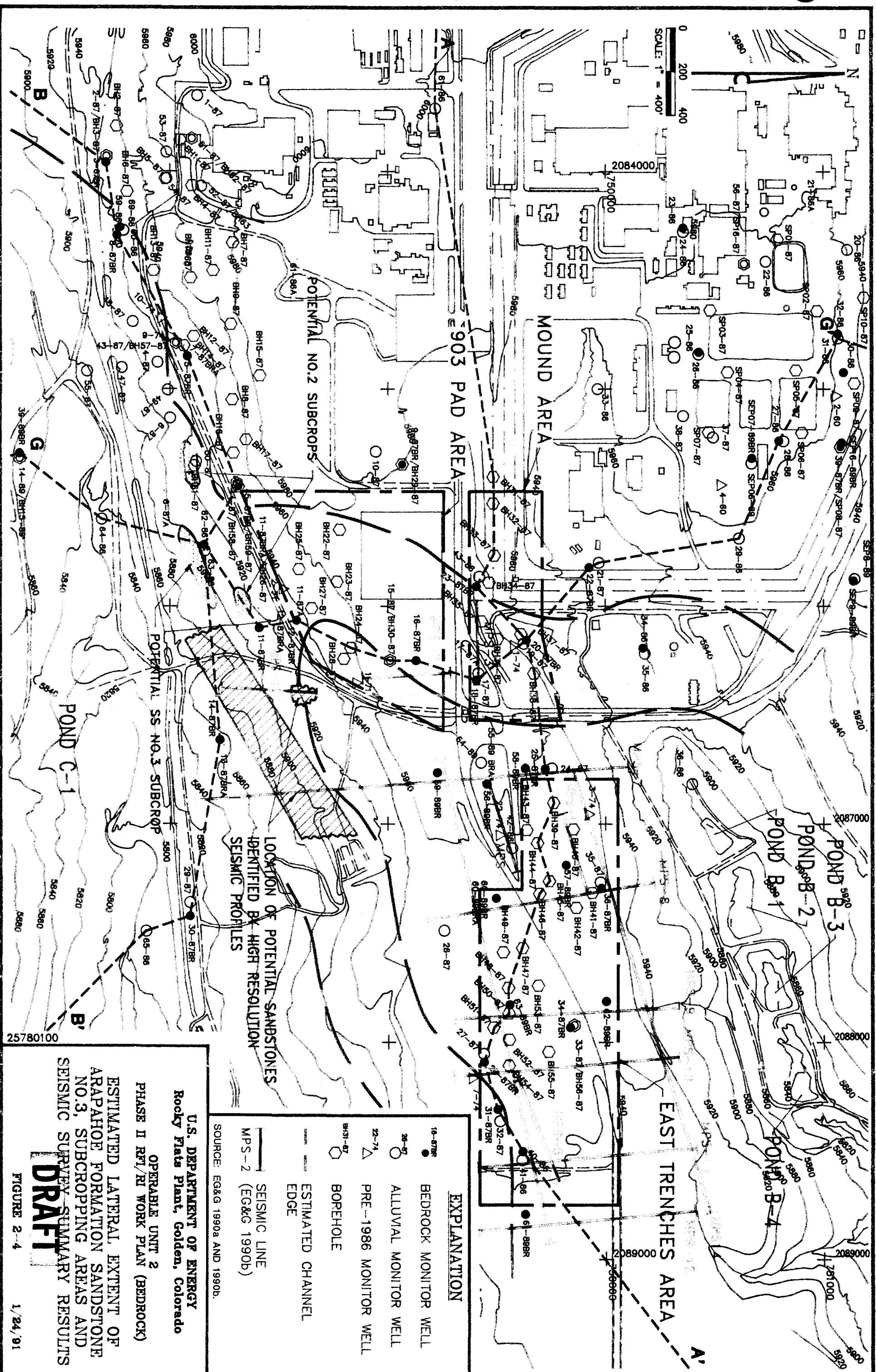
- CONTACT
DASED WHERE APPROXIMATELY LOCATED,
DASED WHERE NEEDED.
- ARTIFICIAL FIL
PAVEMENT OR GRAVEL
DISTURBED GROUND
- QUATERNARY
RECENT VALLEY FIL
LANDSLIDE
COLLUVIAL
TERRACE ALLUVIAL
SLOPE ALLUVIAL
VERDOL ALLUVIAL
ROCKY FLATS ALLUVIAL
- Qol
Qc
Qs
Qv
Qrt
Ka
Kss
- GEOTECNICAL
ANPAK FORMATION, SANDSTONE
ANPAK FORMATION, CLAYSTONE

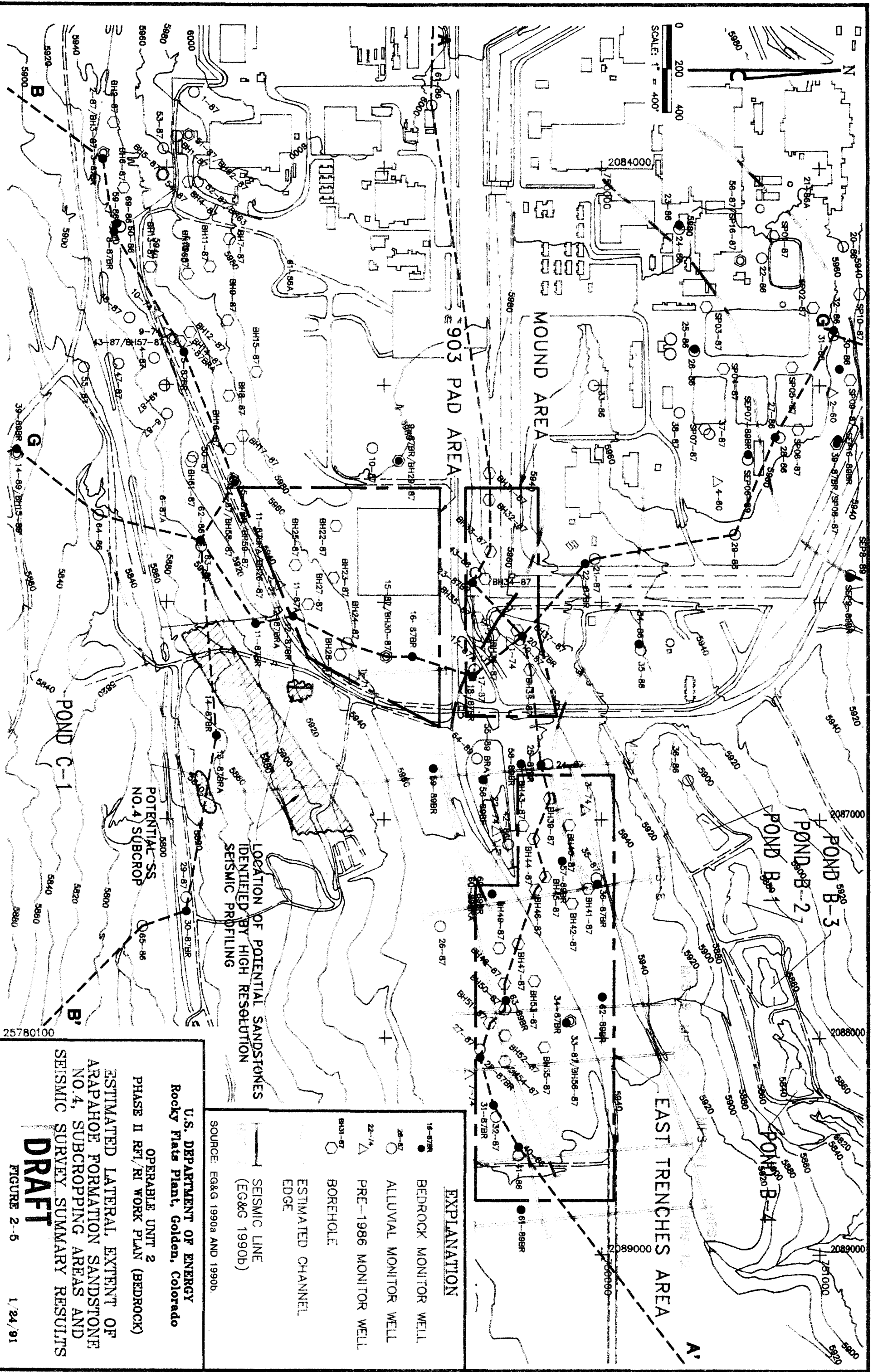
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Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

SURFICIAL GEOLOGY









U.S. DEPARTMENT OF ENERGY
 Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
 PHASE II REL/RI WORK PLAN (BEDROCK)

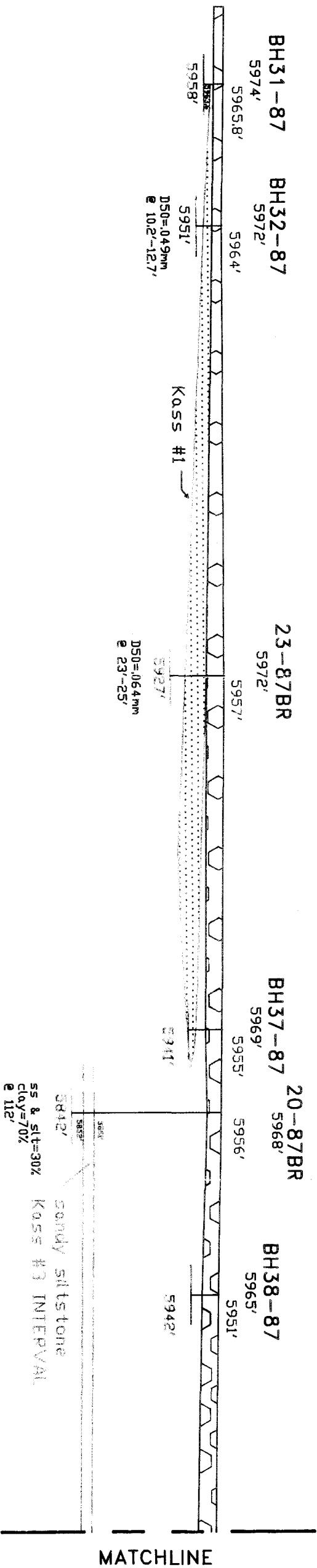
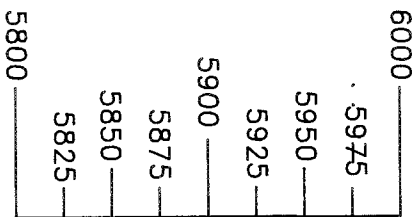
ESTIMATED LATERAL EXTENT OF
 ARAPAHOE FORMATION SANDSTONE
 NO.4, SUBCROPPING AREAS AND
 SEISMIC SURVEY SUMMARY RESULTS

DRAFT

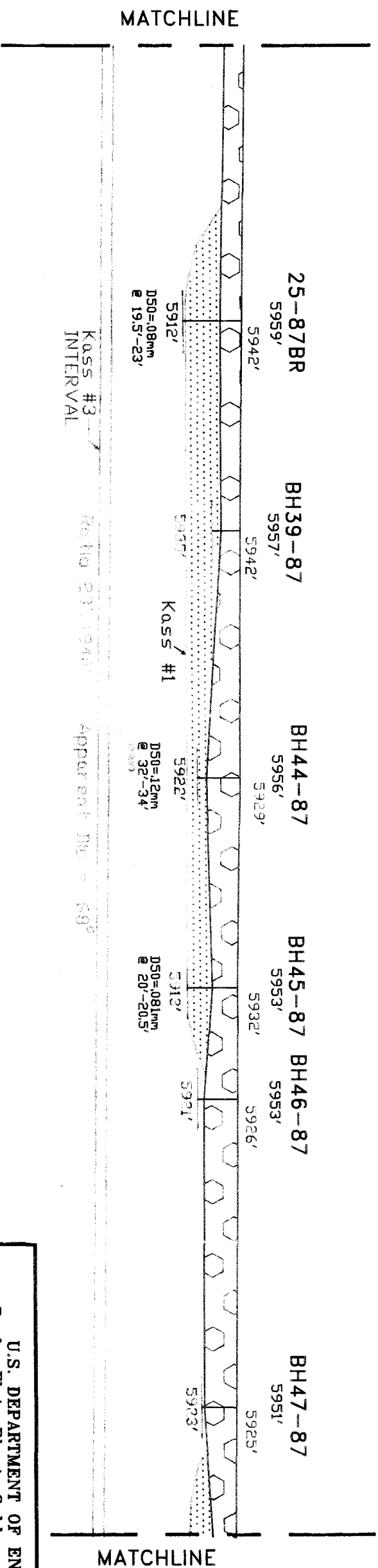
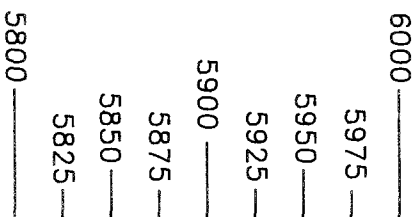
FIGURE 2-5 1/24/91

- EXPLANATION**
- BEDROCK MONITOR WELL
 - ALLUVIAL MONITOR WELL
 - △ PRE-1986 MONITOR WELL
 - BOREHOLE
 - ESTIMATED CHANNEL EDGE
 - SEISMIC LINE (EG&G 1990b)
- SOURCE: EG&G 1990a AND 1990b.

ELEVATION IN FEET (MSL)



ELEVATION IN FEET (MSL)



EXPLANATION

Qc = Colluvium
Qf = Rocky Flats Alluvium
KASS = Arapahoe Formation Sandstone

5968' = Ground Surface Elevation
5956' = Bedrock Surface Elevation

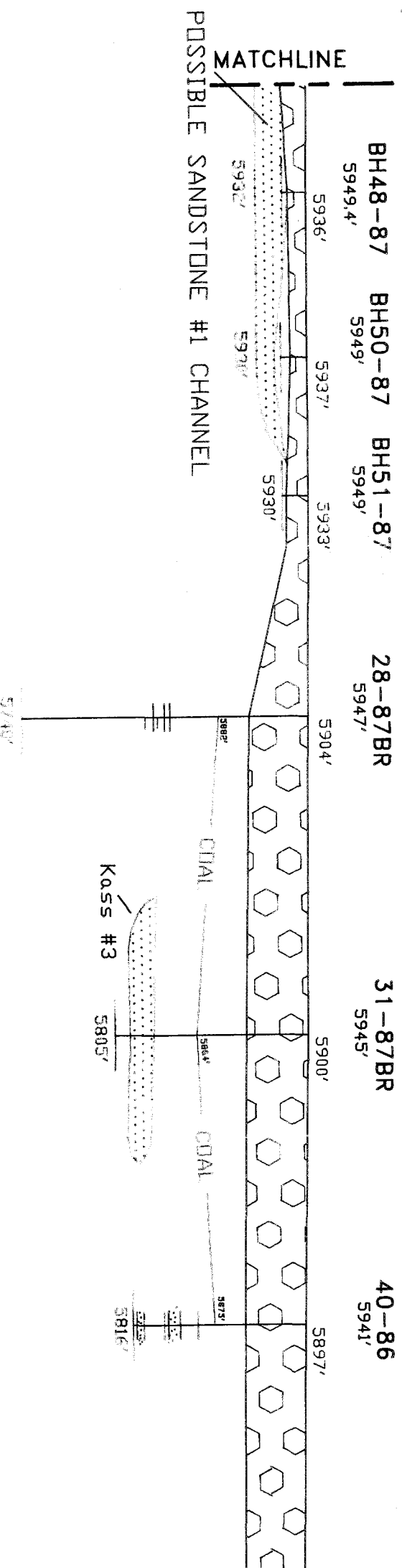
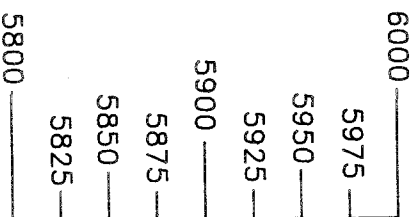
Source: EG&G 1990a

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OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)
GEOLOGIC CROSS-SECTION A-A'

FIGURE 2-6A

1-24-91

ELEVATION IN FEET (MSL)



EXPLANATION

Cc = Colluvium

Qrf = Rocky Flats Alluvium

Kass = Arapahoe Formation Sandstone

5968' = Ground Surface Elevation

5956' = Bedrock Surface Elevation

5842 = Section at Bedrock Elevation

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Rocky Flats Plant, Golden, Colorado

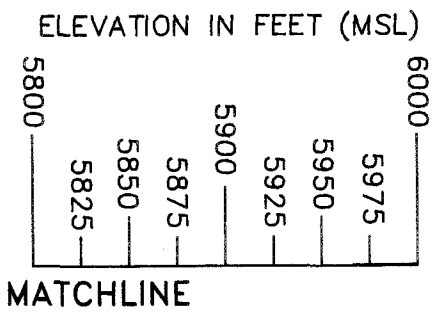
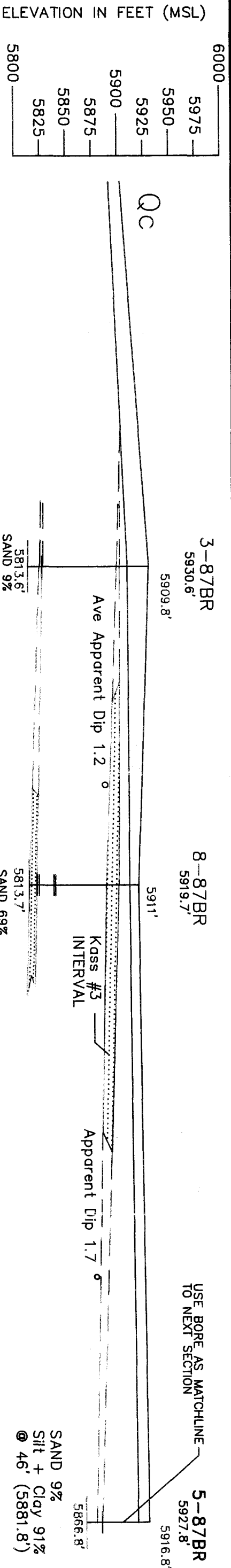
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

GEOLOGIC CROSS-SECTION A-A'

Source: EG&G 1990a

FIGURE 2-6B

1-24-91



MATCHLINE

Cretaceous
Arapahoe Formation
Laramie Formation

5837.4'
SAND 11%
Clay + Silt 86%
Gravel 3%?
SAND 22%
Silt + Clay 15%
Gravel 63%
@ 98' (5851.4')

5838.24'
D50=.0037mm
SAND 24%
Gravel 27%
@ 10.3-12.5' (5886.5')

D50=.0052mm
SAND 16%
@ 40.3-42.8' (5856')

D50=.094mm
SAND 55%
@ 55.3-57.8' (5841.5')

5838.24'

62-86
5897.54'
5875.54'

QC

MATCHLINE

EXPLANATION

Qc = Colluvium
Qrf = Rocky Flats Alluvium
Kass = Arapahoe Formation Sandstone

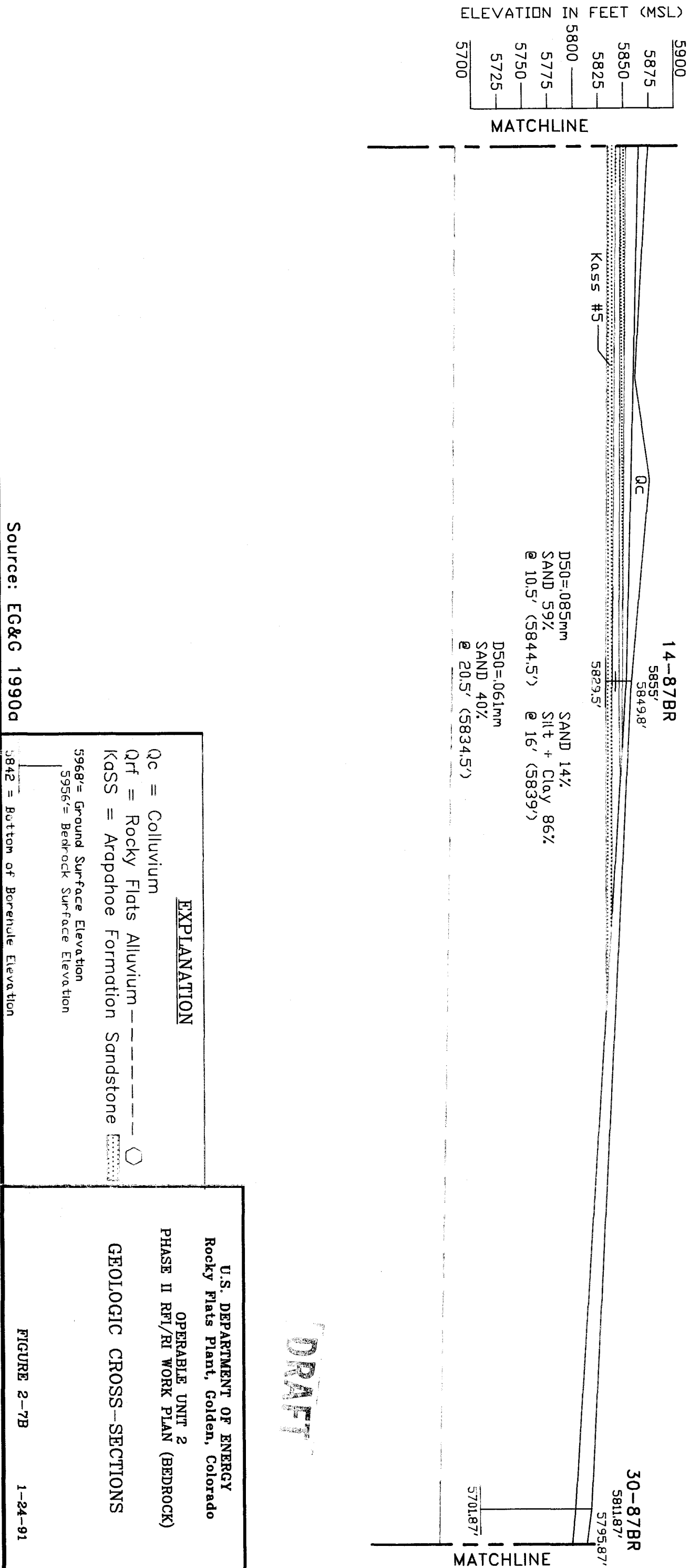
5968' = Ground Surface Elevation
5956' = Bedrock Surface Elevation

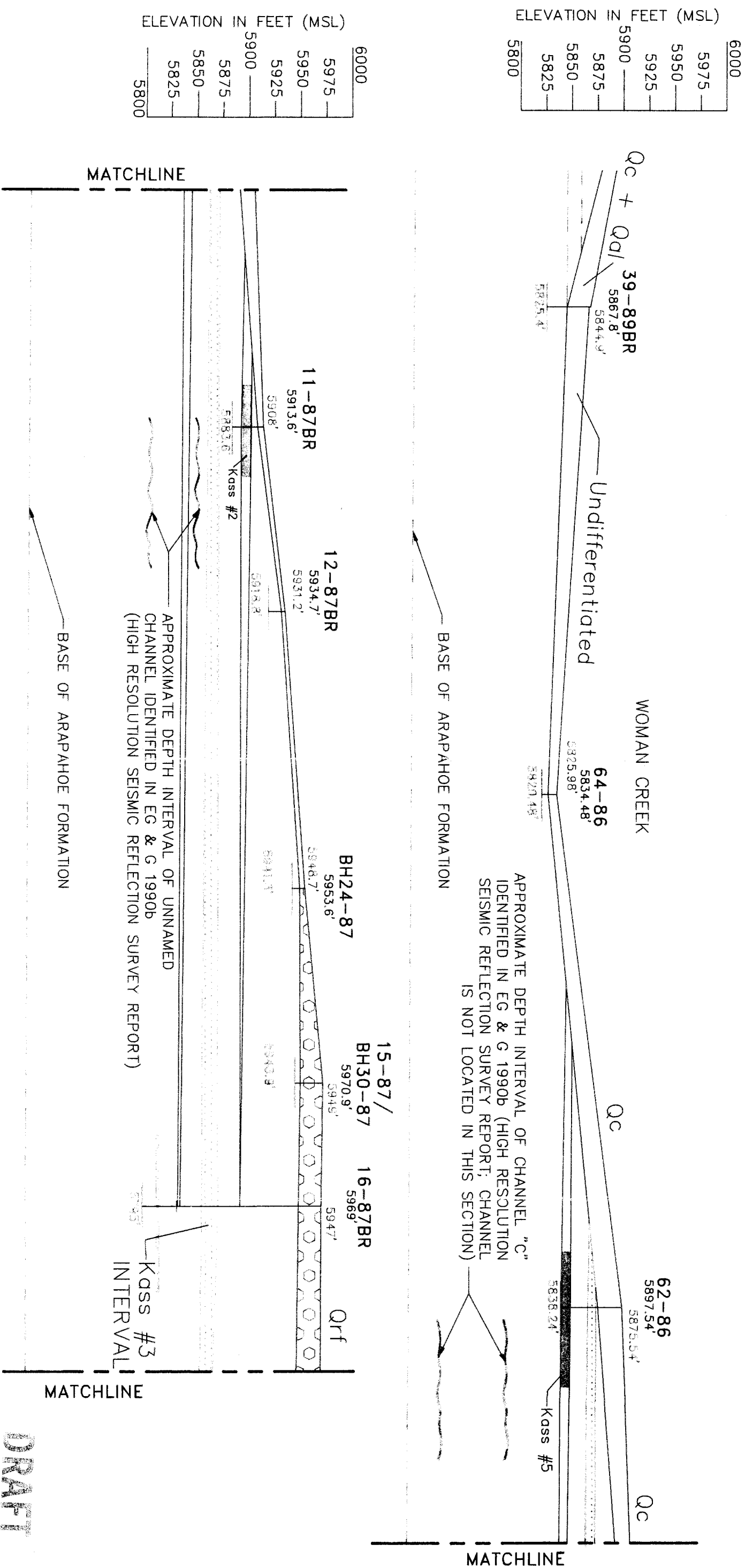
Source: EG&G 1990a

5842 = Bottom of Borehole Elevation

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Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)
GEOLOGIC CROSS SECTIONS B-B'

DRAFT



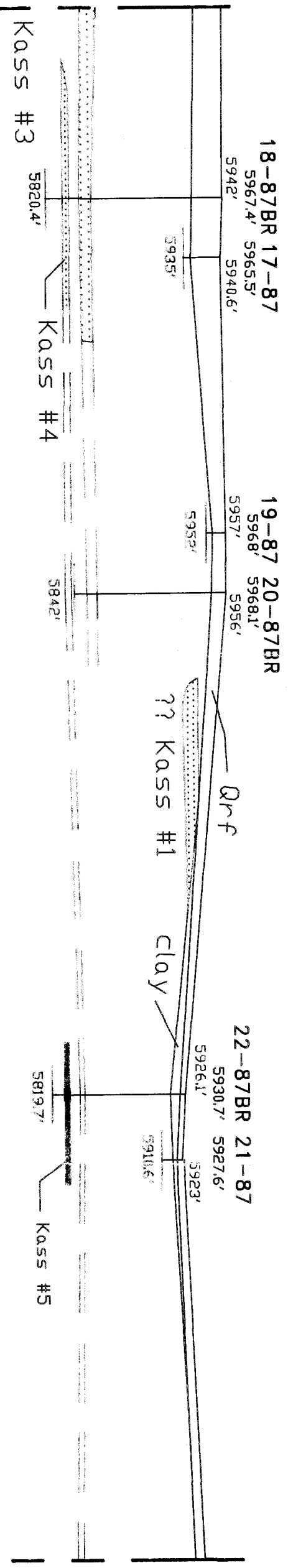
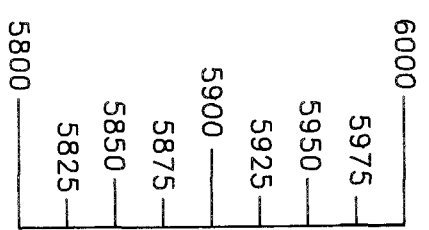


Source: EG&G 1990a

FIGURE 2-8A

1/24/91

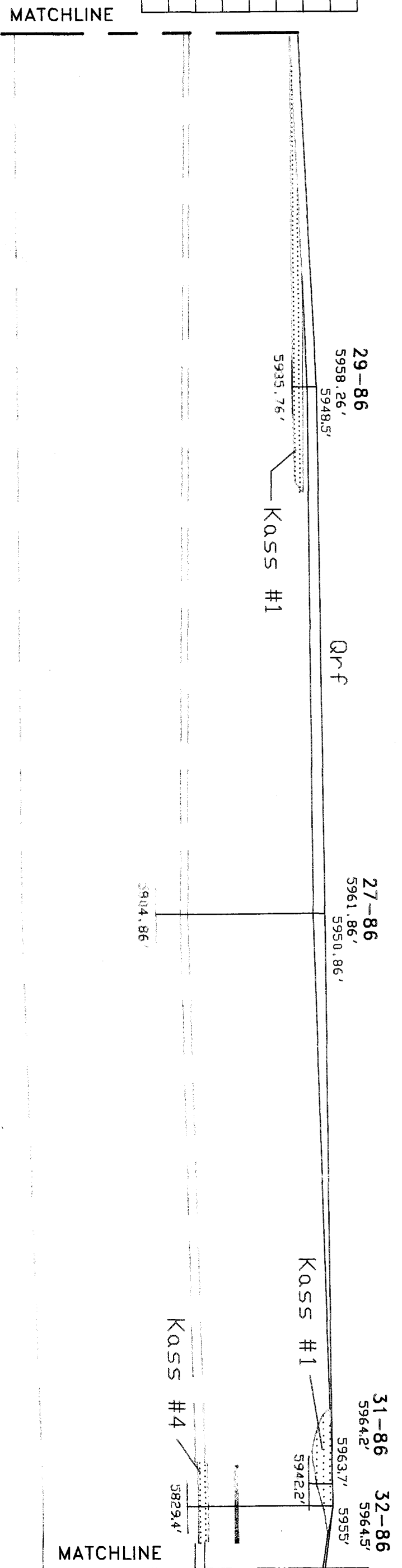
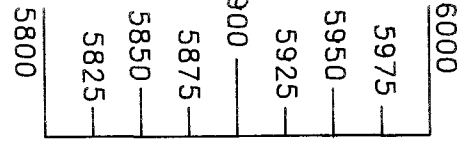
ELEVATION IN FEET (MSL)



MATCHLINE

MATCHLINE

ELEVATION IN FEET (MSL)



MATCHLINE

MATCHLINE

EXPLANATION

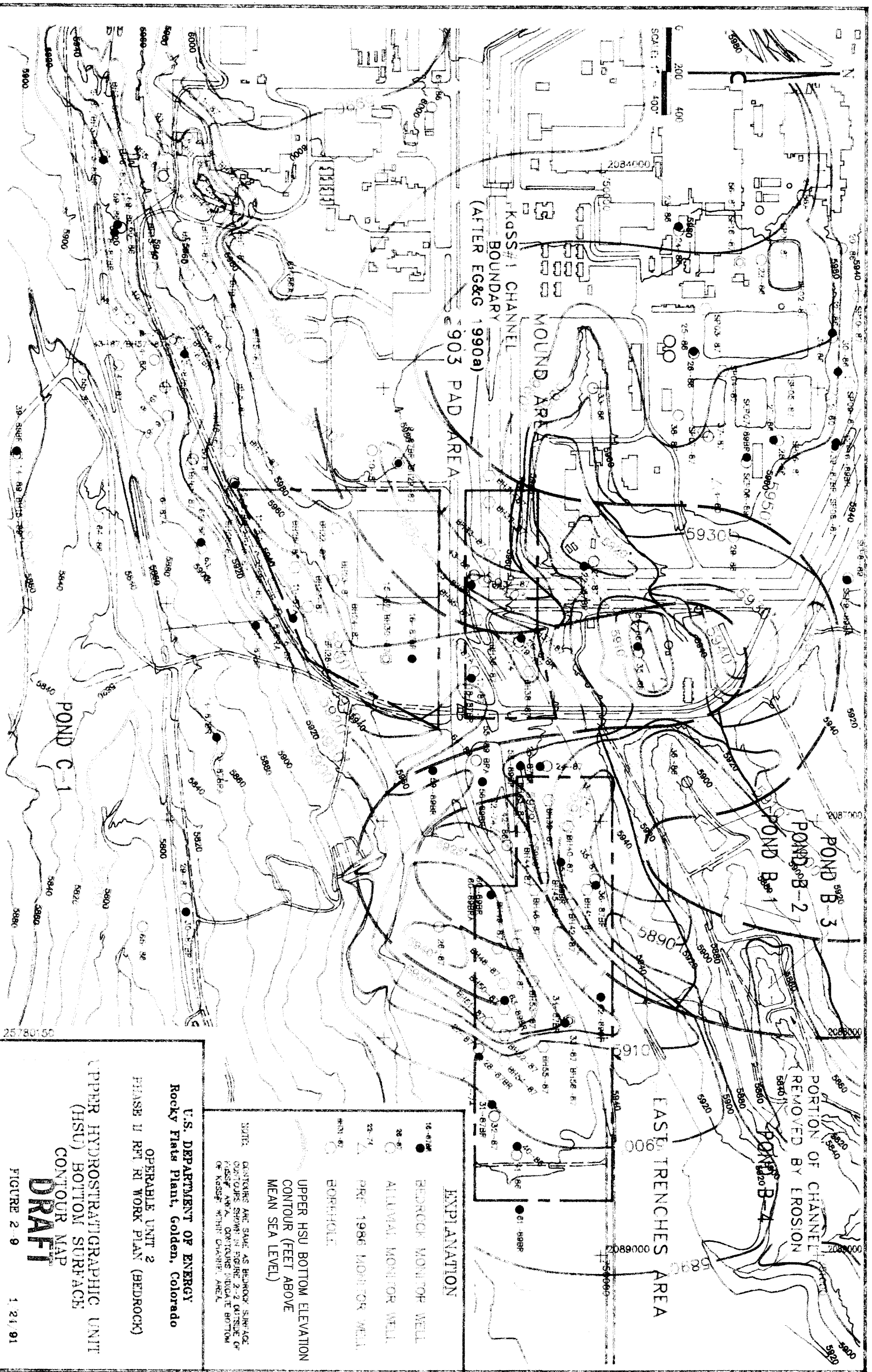
- Qc = Colluvium
- Qrf = Rocky Flats Alluvium
- KASS = Arapahoe Formation Sandstone

5968' = Ground Surface Elevation
5956' = Bedrock Surface Elevation

5842' = Bottom of Borehole Elevation

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Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)
GEOLOGIC CROSS-SECTION G-G'





EXPLANATION

- BEDROCK MONITOR WELL
- ALLIUM MONITOR WELL
- △ PRE-1986 MONITOR WELL
- BOREHOLE

UPPER HSU BOTTOM ELEVATION
CONTOUR (FEET ABOVE
MEAN SEA LEVEL)

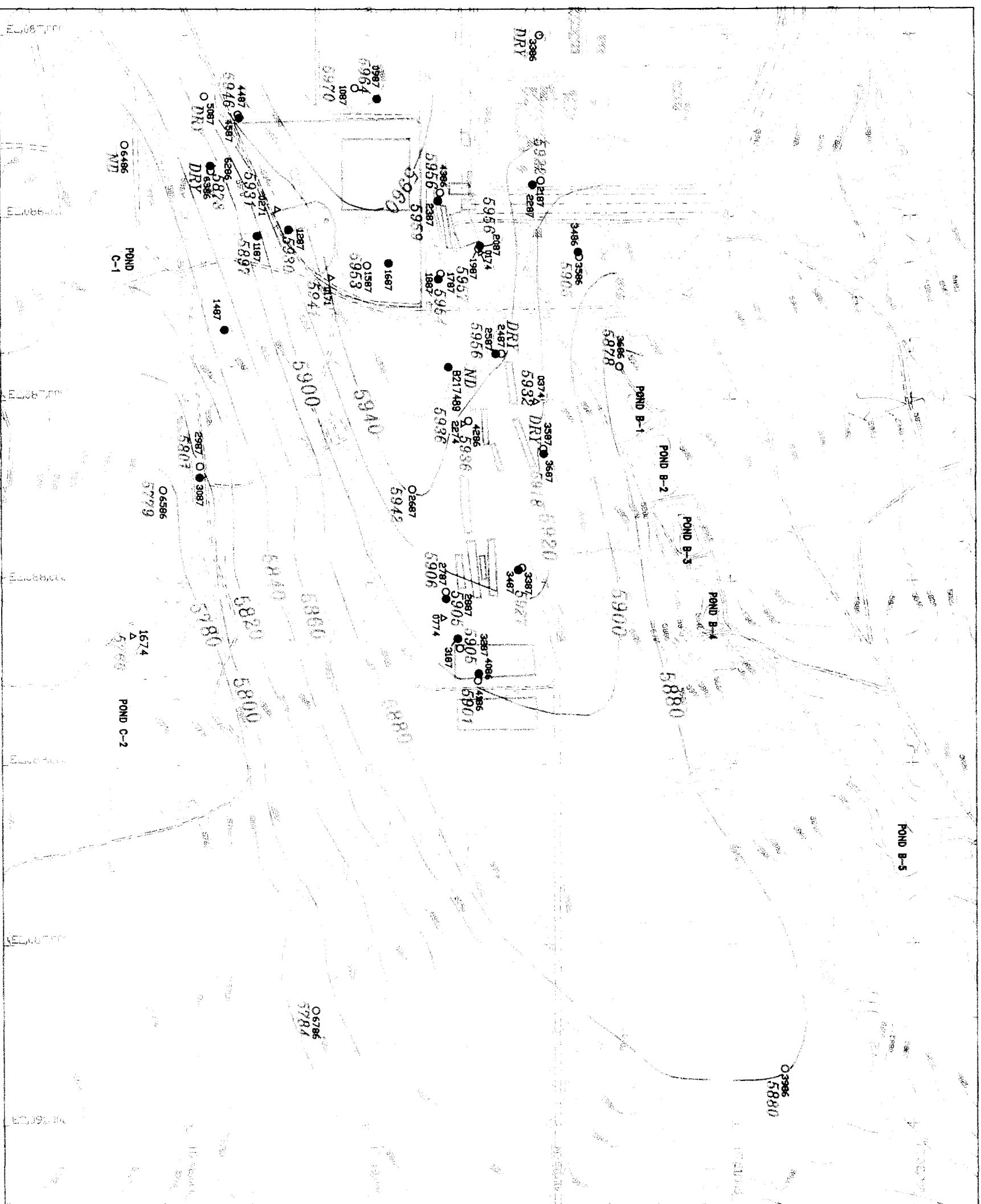
NOTE: CONTOURS ARE SAME AS BEDROCK SURFACE
CONTOURS SHOWN IN FIGURE 2-2 OUTSIDE OF
PADS. AREA CONTOURS INDICATE BOTTOM
OF KASS#1 CHANNEL AREA.

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Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
PHASE II RI WORK PLAN (BEDROCK)

UPPER HYDROSTRATIGRAPHIC UNIT
(HSU) BOTTOM SURFACE
CONTOUR MAP

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Scale: $1'' = 600'$

0' 300' 600'

CONTOUR INTERVAL = 20'

DRF

EXPLANATION

INDIVIDUAL HAZARDOUS SUBSTANCE SITE
(IHSS)

POTENTIOMETRIC SURFACE
ELEVATION (feet above
mean sea level)

ALL DATA BASED ON MEASUREMENTS
MADE APRIL 4-8, 1988 INCLUSIVE

5860
LINE OF EQUAL POTENTIOMETRIC
SURFACE ELEVATION (feet
above mean sea level) - DASHED
WHERE APPROXIMATELY LOCATED

ND

NO DATA

B217489 • BEDROCK MONITOR WELL

B213789 O ALLUMAL MONITOR WELL

0382 Δ PRE-1986 MONITOR WELL.

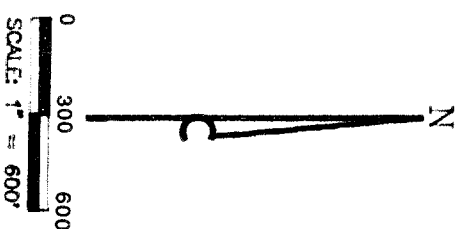
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2 PHASE II RFI/RI WORK PLAN (BEDROCK)

POTENTIOMETRIC SURFACE OF UPPER HYDROSTRATIGRAPHIC UNIT (HSU)

FIGURE 2-11

1/24/01



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EXPLANATION

INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)

LINE OF EQUAL CO₂ CONCENTRATION (PPM)

DASHED WHERE APPROXIMATELY LOCATED

NOTE: DATA VALUES SHOWN IN 1986 1990c

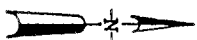
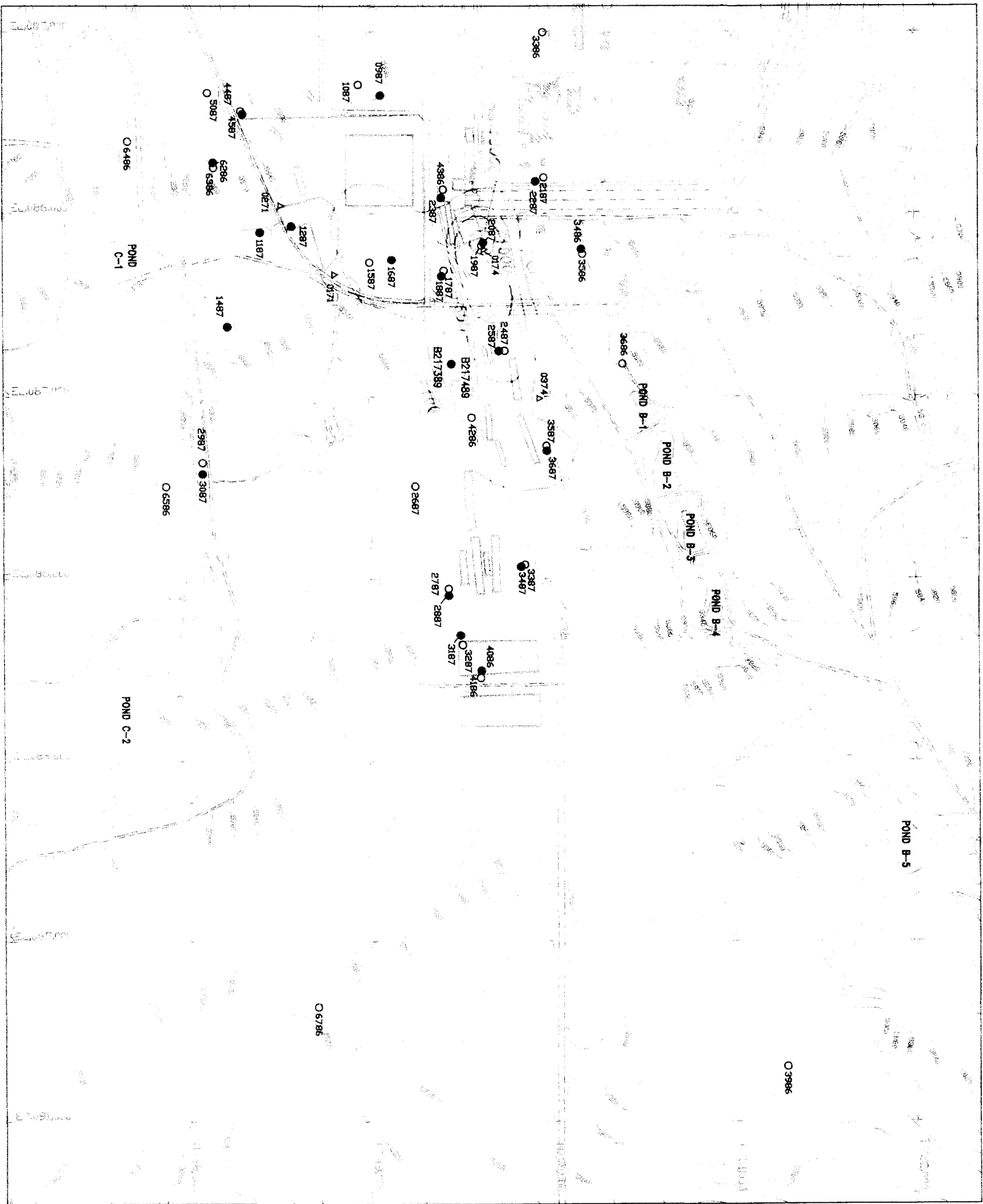
- B217489 ● BEDROCK MONITOR WELL
- B213789 ○ ALLIUM MONITOR WELL
- 0392 ▲ PRE-1986 MONITOR WELL

SOURCE: ES&S 1990c

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Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
PHASE II RPT/RI WORK PLAN (BEDROCK)

CARBON TETRACHLORIDE ISOPLETHS
FOR THE UPPER HYDROSTRATIGRAPHIC
UNIT



Scale: 1" = 600'
0' 300' 600'
CONTOUR INTERVAL = 20'

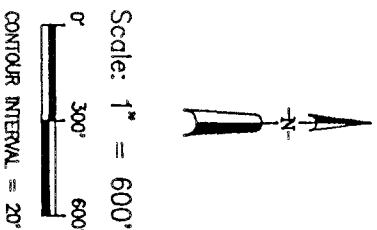
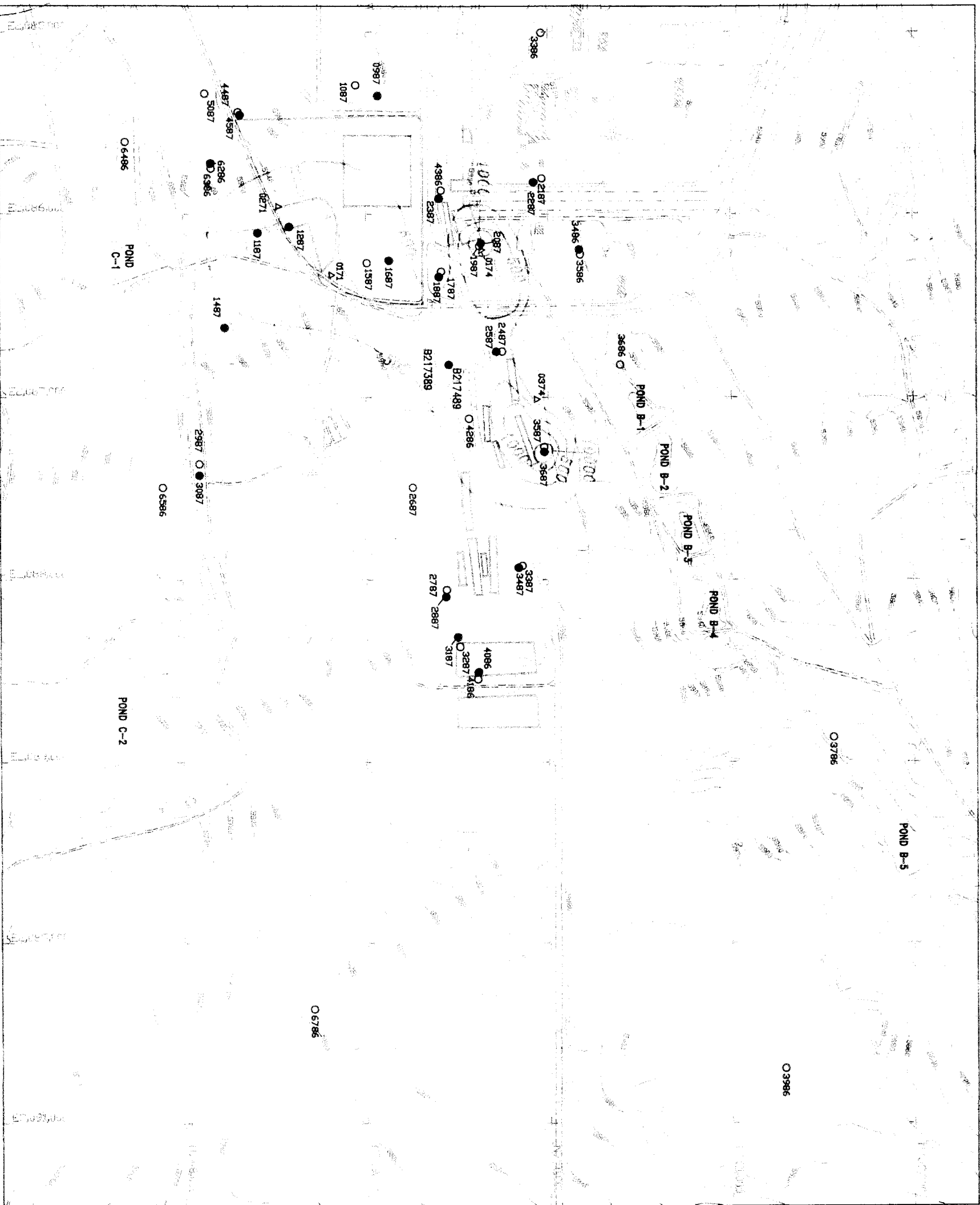
DRAFT

EXPLANATION

- INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)
- LINE OF EQUAL PCE CONCENTRATION (ug/l)
DASHED WHERE APPROXIMATELY LOCATED
- NOTE: DATA VALUES SHOWN IN E546 1990c
- B217489 ● BEDROCK MONITOR WELL
- B213789 ○ ALLUVIAL MONITOR WELL
- 0382 ▲ PRE-1986 MONITOR WELL

SOURCE: E G & G 1990c

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Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFL/RJ WORK PLAN (BEDROCK)
TETRACHLOROETHYLENE ISOPLETHS
FOR THE UPPER
HYDROSTRATIGRAPHIC UNIT



DRAFT

EXPLANATION

INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)

LINE OF EQUAL TCE CONCENTRATION (µg/l)
DASHED WHERE APPROXIMATELY LOCATED

NOTE: DATA VALUES SHOWN IN EG&G 1890c

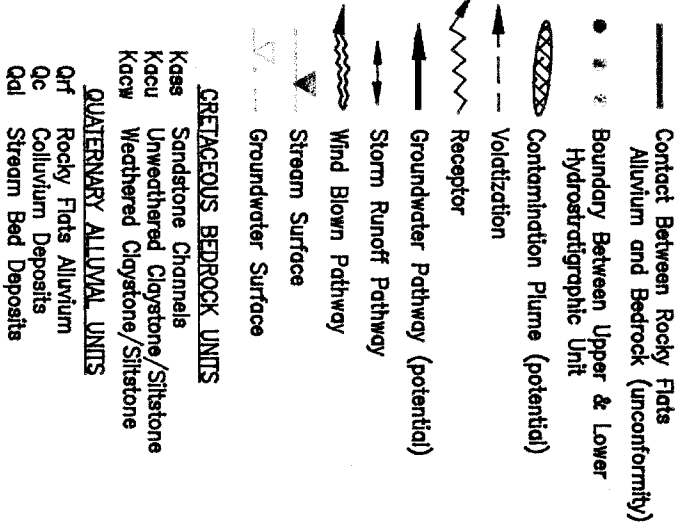
- BEDROCK MONITOR WELL
- ALLUVIAL MONITOR WELL
- △ PRE-1986 MONITOR WELL

SOURCE: E G & G 1990c

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Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)
TRICHLOROETHYLENE ISOPLETHS
FOR THE UPPER
HYDROSTRATIGRAPHIC UNIT












FIGURE 2-23

1/24/91



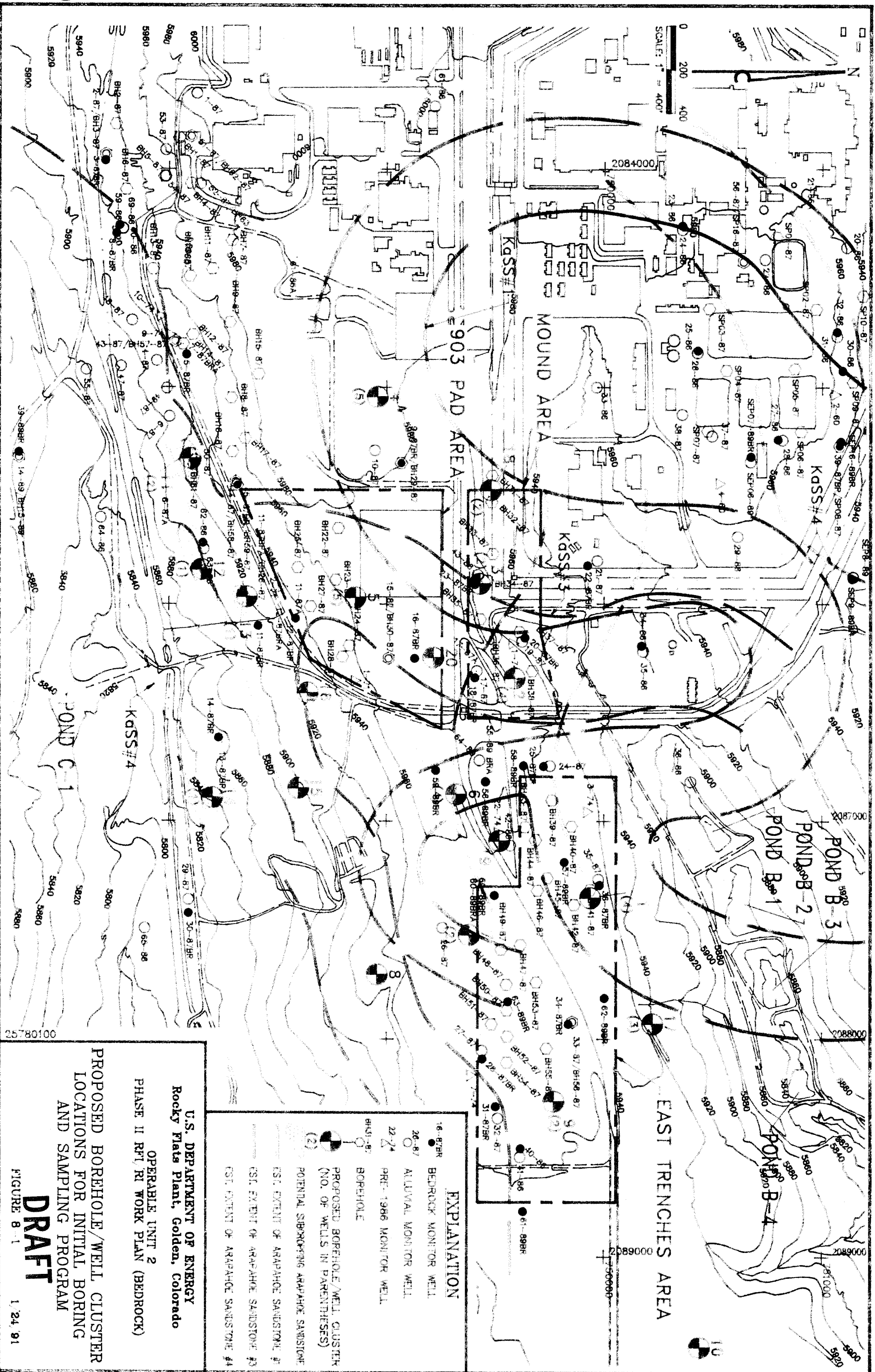
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EXPLANATION

- | | |
|---|---|
|  | Contact Between Rocky Flats |
|  | Alluvium and Bedrock (unconformity) |
|  | Boundary Between Upper & Lower
Hydrostratigraphic Unit |
|  | Contamination Plume (potential) |
|  | Volatilization |
|  | Receptor |
|  | Groundwater Pathway (potential) |
|  | Storm Runoff Pathway |
|  | Wind Blown Pathway |
|  | Stream Surface |
|  | Groundwater Surface |
-
- | |
|---|
| <u>CRETACEOUS BEDROCK UNITS</u> |
| Kass Sandstone Channel |
| Kocu Unweathered Claystone/Siltstone |
| Kacw Weathered Claystone/Siltstone |
| <u>QUATERNARY ALLUVIAL UNITS</u> |
| Qr Rocky Flats Alluvium |
| Qc Colluvium Deposits |
| Qd Stream Bed Deposits |

NOT TO SCALE

**U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT NO. 2
PHASE II RTI/RI WORK PLAN (BEDROCK)
SITE CONCEPTUAL MODEL**



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
PHASE II RPT RI WORK PLAN (BEDROCK)

PROPOSED BOREHOLE/WELL CLUSTER
LOCATIONS FOR INITIAL BORING
AND SAMPLING PROGRAM

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FIGURE 8-1 1/24/91